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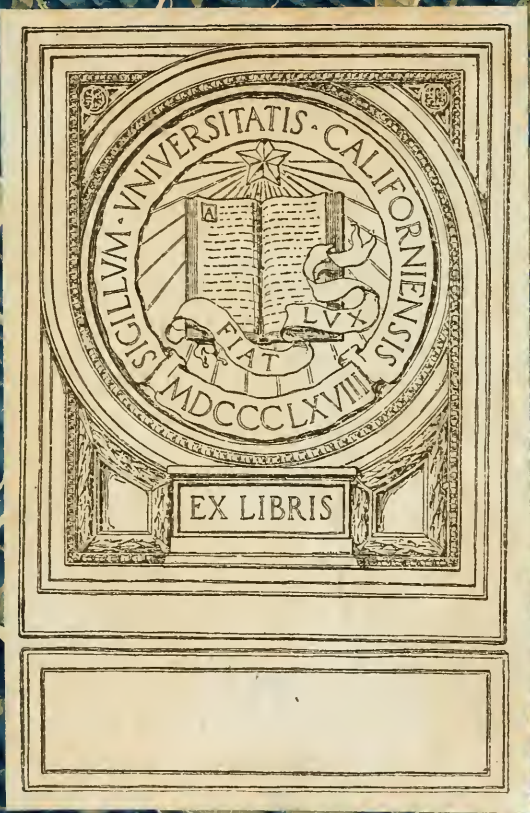
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HOME ECONOMICS

A COMPLETE HOME-STUDY COURSE

ON THE NEW PROFESSION OF HOME-MAKING AND ART OF RIGHT LIVING;
THE PRACTICAL APPLICATION OF THE MOST RECENT ADVANCES
IN THE ARTS AND SCIENCES TO HOME AND HEALTH

PREPARED BY TEACHERS OF RECOGNIZED AUTHORITY

FOR HOME-MAKERS, MOTHERS, TEACHERS, PHYSICIANS, NURSES, DIETITIANS,
PROFESSIONAL HOUSE MANAGERS, AND ALL INTERESTED
IN HOME, HEALTH, ECONOMY AND CHILDREN

TWELVE VOLUMES

NEARLY THREE THOUSAND PAGES, ONE THOUSAND ILLUSTRATIONS
TESTED BY USE IN CORRESPONDENCE INSTRUCTION
REVISED AND SUPPLEMENTED

CHICAGO
AMERICAN SCHOOL OF HOME ECONOMICS
1907

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WASHING DAY

CHEMISTRY OF THE HOUSEHOLD

BY
MARGARET E. DODD, S. B.
GRADUATE OF MASSACHUSETTS INSTITUTE OF TECHNOLOGY
TEACHER OF SCIENCE, WOODARD INSTITUTE

CHICAGO
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1907

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AMERICAN SCHOOL OF HOME ECONOMICS

CHICAGO

January 1, 1907.

My dear Madam:

The chemistry of housework is a subject so varied that new problems arise almost every day and new methods of attacking old problems are constantly to be discovered. In all this complication, a few underlying principles are unalterable and will help us to right conclusions.

These lessons are by no means complete and an experienced housekeeper will think of many questions which are unanswered and methods of work that she herself employs which are not mentioned here. I hope that you will tell me of your own methods and experiences and I especially want you to ask questions so that we may supplement the lessons together.

Many of the subjects which are only touched upon in this series are taken up fully from a different standpoint in later lessons.

I am indebted to my revered friend and teacher, Mrs. Ellen H. Richards, for the suggestion of the treatment of the subject in the order of "A Day's Chemistry" and for the use of material in her published books.

There is no BEST rule of universal application for circumstances vary so widely, but the reason why some methods produce good results are here set forth.

In the study of these lessons I would advise taking up one subject at a time, illustrating it by the experiments suggested and by others

which may occur to you. After considering each topic in detail in this way, read the whole lesson over carefully. When puzzled over anything, make a note of the difficulty and if you do not discover an explanation for yourself, write to the School for assistance.

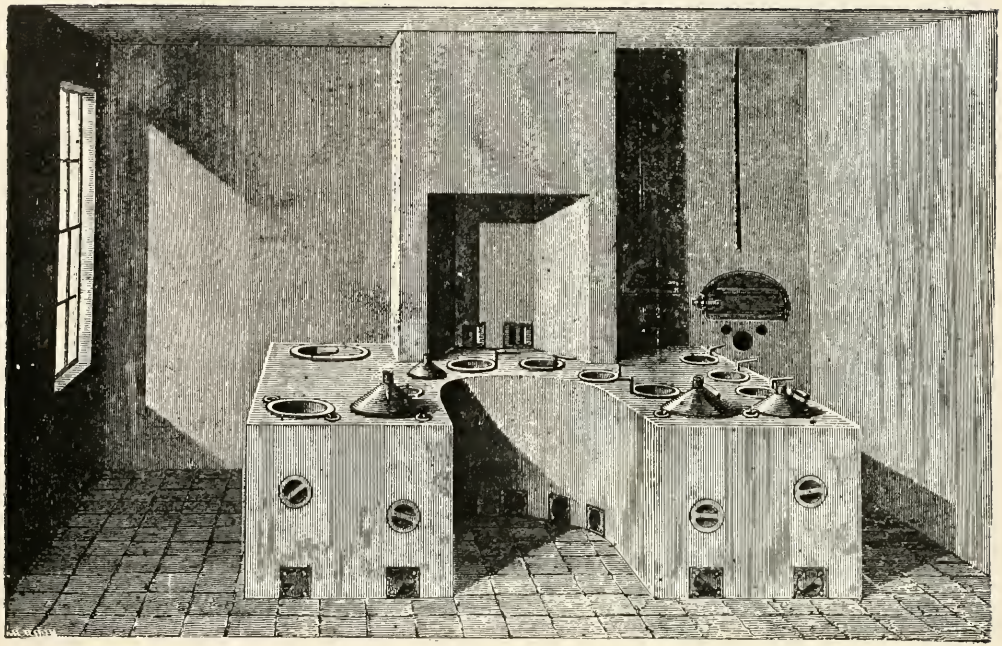
As you know from your own experience, work that really interests does not prove as fatiguing as mere drudgery. An intelligent interest in the reason "why" of daily happenings will surely make your daily duties go more easily and may lead you to discover simpler and more effective methods.

And so I wish you much success and pleasure in following this brief study of "A Day's Chemistry".

Very sincerely yours,

Margaret E. Dodd

Instructor



COUNT RUMFORD'S KITCHEN IN WHICH HE MADE EXPERIMENTS ON FUEL AND COOKING

Courtesy of Mrs. Ellen H. Richards

CHEMISTRY OF THE HOUSEHOLD

A Day's Chemistry

BEING an outline of the simplest and most evident chemical changes suggested by a day's work at home and a description of the various chemical substances of interest to the housewife.

WATER

Its Occurrenc

The morning bath will introduce us agreeably to the wonderful chemical substance, water, and with this substance we will begin our study of a day's chemistry. The water for the house may come from the town supply, from wells, cisterns, or springs. It may be "surface water," from pond, lake, or stream, or it may be "ground water," from wells or deep springs. Cistern water is, of course, rain water. Water is present in many substances where we might not suspect it. All living things contain a large percentage of water. Of an athlete weighing 150 pounds, all but about 42 pounds is water. Wood, meat, vegetables, fruit, when dried, weigh from 50 to 98 per cent less. Many natural and artificial substances owe their crystalline form to

water and when heated, give off this "water of crystallization" and crumble to powder. Common washing soda shows this effect, when exposed to the air, and soon gives off so much water that its crystalline character is lost.

Natural Water

All water found in nature is more or less impure, that is, it contains substances in solution. It dissolves air and takes substances from the soil and rocks over which it runs. Often it comes in contact with animal and vegetable substances and dissolves something from them. Near dwellings the water in streams, ponds, and wells is very likely to become contaminated. Decaying substances give rise to materials easily dissolved in water, which may travel for a considerable distance under ground, so that the drainage from the house or barn is frequently carried to near-by streams or wells, making their waters quite unfit to drink. Fig. 1.

The following experiment will illustrate that air is dissolved in water.

Experiment. Place a tumbler of fresh well-water or tap-water in a warm place. After a time, bubbles will be seen collecting on the sides of the glass. This is air which was dissolved in the water. As the water grows warm, it cannot hold so much air in solution and some of it separates.

Distilled Water

Most of the impurities in water are less easily converted into vapor than the water itself; hence, when the water is boiled, they stay behind while the water "boils away". Water from almost any source can be made pure and clear by distillation. Distilled water is

prepared in an apparatus known as a still. See Fig. 2. A still consists of a boiler, A, and a condenser. In the condenser, a coil of tube, D, usually made of pure

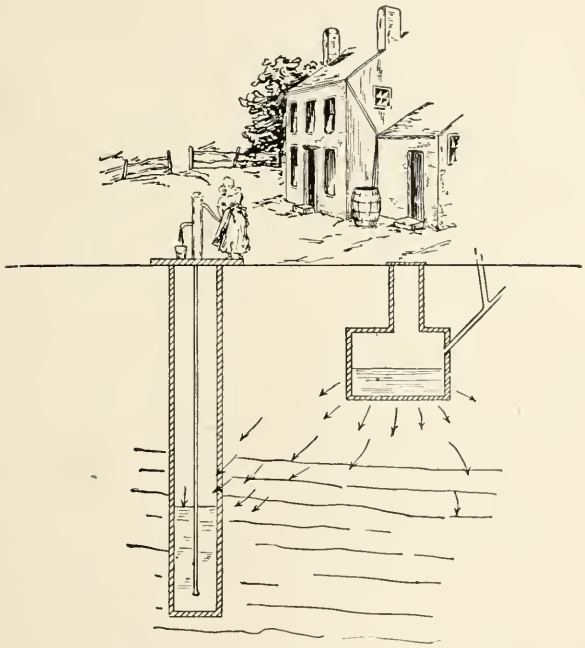


FIG. 1. WELL, CONTAMINATED BY HOUSE DRAINAGE.

tin, is surrounded by cold water which continually runs through the apparatus. The steam, admitted at the upper end of the coil, is condensed by the low temperature and distilled water is collected at the lower

end. In the laboratory, distilled water is often made in the glass apparatus shown in Fig. 3.

Distilled water has a flat taste, because air and other dissolved substances which give water its taste have been removed. It will again dissolve the air on being poured several times from one vessel into another.

Rain Water

Rain is water which has been evaporated from the surfaces of natural bodies of water, oceans, lakes, and from the land, and is practically free from mineral matter, but contains dissolved gases.

The vapor, cooled at the low temperatures of the upper levels of air, falls as rain. The first fall of any

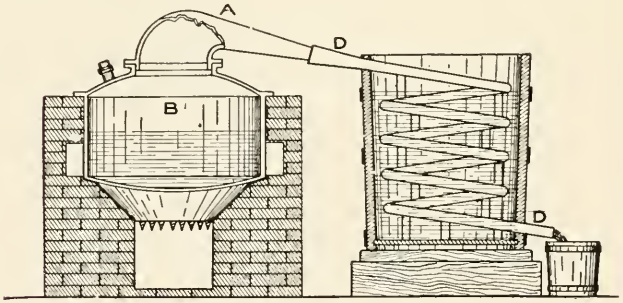


FIG. 2. A STILL.
A, Gooseneck; B, Boiler; D, Condensing Coil.

shower is mixed with impurities which have been washed from the air. Among these may be carbon dioxide, ammonia, and carbon in the form of soot and creosote. It is these last impurities which cause the

almost indelible stain left when rain water stands upon window-sills or other finished woods.

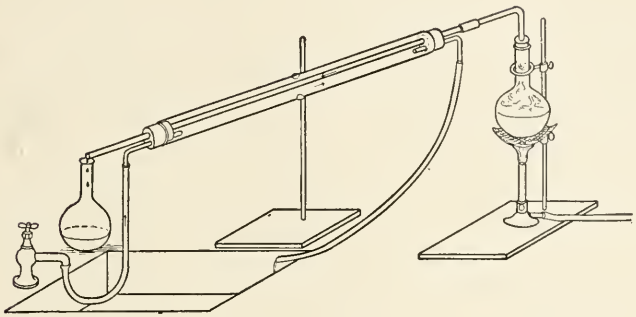


Fig. 3. Making Distilled Water in the Laboratory.

Solubility

Water is a nearly universal solvent. It dissolves more substances and these in larger quantities than any other liquid. At a given temperature, water will dissolve only a certain proportion of the various salts and other soluble substances. When the water will take up no more, the solution is said to be *saturated.* Increasing the temperature generally increases the dissolving power of water for solids and liquids. The reverse is usually true for gases.

When a saturated solution of a solid is cooled, crystals are frequently formed, many having beautiful shapes. Examples are shown in Fig. 4.

Experiment. In an earthen-ware or enameled dish dissolve as much alum as possible in a little boiling water. Pour the solution into a shallow dish or sau-

cer, and set it away for a day or more where it will be undisturbed. Beautiful, clear, six-sided crystals will form in the dish. If strings are hung in the solution, the crystals will form upon them. Rock candy crystals are made from cane sugar syrup in this way.

The experiment may be repeated, using washing soda instead of alum.

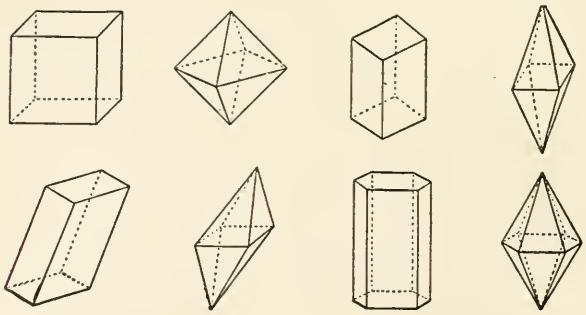


FIG. 4. SHAPES OF CRYSTALS.

Effect of Water on Metals

Silver, copper, and tin are not perceptibly dissolved in pure water, but when combined with acid substances, the compounds formed are soluble. These compounds of a metal with an acid are called salts. The salts of copper, zinc, and lead are poisonous. Copper, brass, (an alloy of copper with zinc) tin, solder, and iron are metals easily affected by acids, so that cooking utensils made of these materials should not be used with acid substances like lemon and vinegar.

Effect of Water on Lead

Lead pipes are much used in plumbing, and as a rule no evil results follow, since ordinary drinking water acts under most circumstances only very slightly upon lead. The pipes are soon coated with a layer of carbonate and sulphate of lead, which is insoluble and prevents any further action. Water from new lead pipes, or pipes not kept constantly full, or from a hot-water system in which lead is used, should never be used for drinking or cooking because of danger from poisoning. Pure distilled water, or rain water, affects lead more than ordinary ground water.

Hard Water

Rain water absorbs more or less carbon dioxide gas from the air and soaking into the soil often comes in contact with magnesia in the rocks and with limestone. Water containing this gas will dissolve these mineral substances making what is known as "hard" water, a very different substance from the original rain water which is "soft." This subject will be discussed when the chemistry of the laundry is explained.

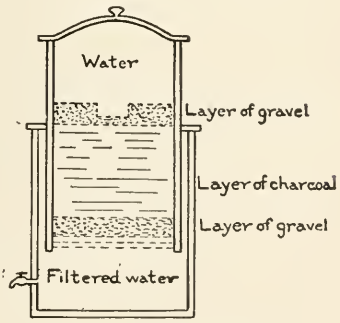


FIG. 5. A WATER FILTER.

Filtering

Ordinary water for drinking purposes is often filtered. Filtration will remove small particles suspended in the water, but has no effect on substances dissolved in it.

The small charcoal or sand filters will not remove

the minute living forms called micro-organisms or germs, some of which are the cause of disease. A filter of porous stone or procelain, in which the water filters slowly, is more effective. A good filter is shown in Figure 5.

Water which has strained or filtered through several feet of earth is often much improved, but the earth filter itself may become contaminated after a while and more harm than good result. A thick layer of sand and rock, however, removes germs effectively, and consequently water from deep driven wells is safe.

Composition of Water

Water was long considered an elementary or simple substance, but towards the end of the last century it was found to consist of two quite different substances so intimately joined together that the identity of each is lost. If we pass an electric current through water in the proper way, we see a gas rising in bubbles from the end of the wire by which the current enters and a like appearance at the wire by which the current leaves the water. The two gases have evidently come from the water and are the substances out of which it is made for the water begins to disappear. By placing an inverted glass filled with water over each wire, the gases are easily collected. See Fig. 6. When one bottle is *full* of gas, the other will be only *half full;* and on decomposing the whole of a given amount of water, this proportion holds true.

If we test these gases, we shall find them quite different. The bottle which is full contains a gas called

hydrogen. There is evidently twice as much of this by volume in water as of the other gas which is called oxygen. These two gases were tied together by what is known as *chemical force,* but the electric current separated them and gave us an opportunity to make the acquaintance of each by itself. We would hardly suppose this clear, colorless liquid to be composed of such material. On decomposing pure water from any

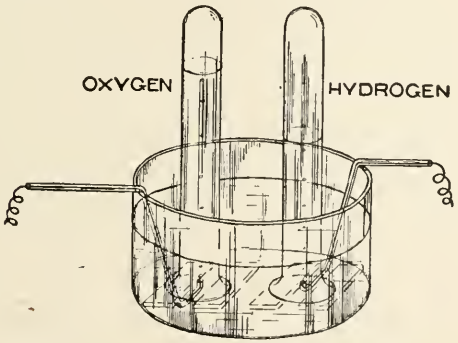


Fig. 6. Decomposing Water Into Oxygen and Hydrogen Gas.

source, the proportion of oxygen to hydrogen is always the same, and in fact, all *chemical compounds* have a *certain composition* which never varies under any condition.

Hydrogen

The name hydrogen comes from two Greek words, meaning *water* and *to produce.* Hydrogen is interesting as being the lightest common substance. It is an invisible gas like air, but unlike air will burn. If a

lighted candle be placed in a bottle of hydrogen, the flame will be at once extinguished, though the hydrogen will take fire at the mouth of the bottle. Fig. 7. Hydrogen will unite with other substances besides oxygen; that is, it will join with other substances by chemical force. It forms a part of most animal and vegetable substances.

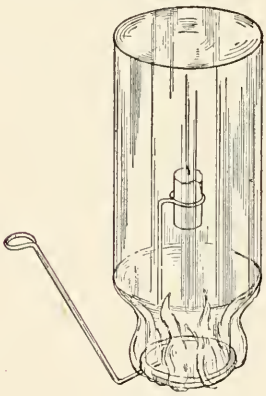


Fig. 7. Hydrogen Will Burn in Air.

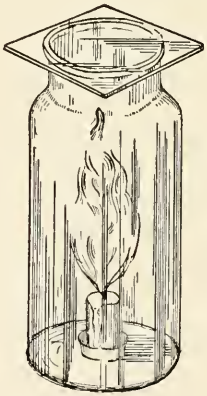


Fig. 8. A Candle Burns Vigorously in Oxygen.

Oxygen

Oxygen, as well as hydrogen, is a tasteless, colorless, odorless gas. The weight of a given volume is sixteen times that of the same volume of hydrogen. It is very abundant and the most important substance to mankind. Should we test this gas with a lighted candle, as we did the hydrogen, we would find that the oxygen would not give a flame, but that the candle would burn far more vigorously. Fig. 8.

When substances burn in oxygen they really unite with it chemically, forming new substances called *oxides*. Water is hydrogen united with oxygen and its chemical name might therefore be oxide of hydrogen.

Effect of Heating Water

When water is heated in an open vessel, evaporation from the surface of the liquid is more rapid as the temperature increases. Soon vapor is formed on the sides and bottom of the vessel and bubbles begin to rise which are at once condensed by the cooler parts of the liquid, thus making the familiar "singing" noise. Finally the liquid becomes so hot that the bubbles reach the surface without condensing, and then the water boils and goes off into the air as steam, an invisible gas. This occupies the small space between the spout of the tea-kettle and the cloud of vapor which is commonly called steam, but is really finely divided drops of water. A cubic inch of water makes about a cubic foot of steam.

Boiling Point

The temperature at which pure water begins to boil at sea level is 212° Fahrenheit (or 100° Centigrade) and this temperature remains the same while the boiling continues. Increasing the heat simply increases the violence of the boiling. The steam given off is of the same temperature as the boiling liquid. Most pure liquids have a definite boiling point; ether boils at 100° F, alcohol at 173° F, turpentine at 315° F.

When the pressure of the atmosphere on the surface of the liquid is less than at the sea level, as on a mountain, where there is not so much air above pressing down on the surface of the liquid, the temperature of

boiling is less. For example, the boiling point of water in Denver, Colorado, is about 202° F, and on the top of some of the mountains in the Himalayas, 180° F. People living in high mountain regions have difficulty in cooking with water or steam.

Increasing the pressure on the surface of the liquid, on the other hand, raises the boiling point. This is seen when water boils in a confined space, as in a steam boiler. Under five pounds pressure of steam, water boils at about 227° F and at 100 pounds pressure, at 337° F.

An increase in the boiling point of water is caused by dissolved substances. A very strong solution of common salt boils at about 226° F, and a solution of sugar—syrup or molasses—boils at an increasing temperature as the water is lost.

The temperature at which a syrup boils, is a measure of its thickness or density. In many modern cookery books temperature tests are given for boiling sugar in making confections, which vary from 215° for a thin syrup, up to 350° for caramel. In making maple sugar a "sugar thermometer" is often placed in the boiling syrup. At a given temperature, which is higher for sugar cakes than for soft sugar, the proper concentration is reached.

Latent Heat

Considerable heat is absorbed by the process of boiling. It requires 966 times as much heat to change a pound of water at the boiling point into steam as it does to raise it one degree Fahrenheit. The heat

which is used to change the state of the water without changing its temperature is called *latent heat* from the Latin word, meaning hidden. The "hidden heat" is given out again when the steam is condensed. This same quantity of heat is absorbed when the water evaporates slowly; hence the great cooling effect of large bodies of water.

Freezing

When water is cooled it shrinks slightly until the temperature of 39° F is reached. On further cooling it to the freezing point, 32° F (or 0° Centigrade) it increases in volume, so that ice takes up more space than the same weight of water and consequently floats. If this were not so, lakes and streams would freeze solid in winter and it is doubtful if they would melt completely during the summer in the northern part of the United States.

To melt ice, 144 times as much heat is required to change the ice at 32° F into water at 32° F, as to raise the temperature of the same quantity of water one degree Fahrenheit. This is the *latent heat of melting* and the same amount of heat is given out when water freezes. Water thus serves as the great temperature regulator for the earth, for by evaporating, much of the heat of summer is absorbed, and before freezing, a great deal of heat must be given out and absorbed.

Heat Absorption

Water has a much greater capacity of absorbing heat than any other common substance. For example, one pound of water will absorb ten times as much heat in being raised one degree as a pound of iron. The great-

er absorbing capacity of water for heat explains why a kettle of fat heats up so much faster than the same weight of water under like conditions; for the fat requires only one-third as much heat to raise it, say, to 200° F, as does the water.

THE ATMOSPHERE

When we leave the sleeping room, we open the windows to admit air. We may with advantage treat our lungs to an air bath by standing at the open window or by going out of doors for a few minutes to take in five or ten deep breaths. Next, perhaps, we shall use drafts of air to help us make a fire in the range or in a fire place.

Air as a Substance

Air is a real substance. It can be weighed. The air in a room 15 feet by 20 feet by 10 feet high weighs 210 pounds, and would fill ten ordinary water pails if liquified. Air will expand and may be compressed like other gases and it has been liquefied by intense cold and pressure. It requires considerable force to move it. When a bottle is full of air, no more can be poured in. Our houses are full of air all the time. It pervades all things—the cells and tissues of our bodies are full of air.

Wood and some metals even contain a little. In breathing we take a little from the room, but it is immediately replaced by expired air, which is impure. Were there no exits for this air, no pure air could enter the house, and we should die of slow suffocation. The

better built the house the quicker the suffocation. Fortunately no house is air tight. Air does pass out through the walls and cracks, and comes in around doors and windows, but unless there is a great difference in the temperature indoors and out, this fresh air is neither sufficient to replace the bad air nor to dilute it beyond harm. Therefore in ordinary weather, the air of all rooms must be often and completely changed either by special systems of ventilation or by intelligent action in the opening of doors and windows.

Air Pressure

The atmosphere surrounds the earth to a depth of fifty miles or more. The effect of gravity of the earth on this mass is to produce a pressure or weight of air on all things. This pressure is about fifteen pounds on each square inch, but we do not notice it, for the pressure is the same on all sides of us and the internal pressure in the cells of our bodies balances the external pressure of the atmosphere.

If it were not for the pressure of the air, we could not drink lemonade through a straw or pump a pail of water. When we exhaust part of the air by suction, we remove part of the pressure over the liquid in the straw and the air pressure on the surface in the glass forces the liquid up the straw. The same principle applies in a pump—the air is partially taken off the top of the water in the pipe, and then the pressure outside forces the water up in the pipe and by a proper valve arrangement, it is made to run into the pail. See Fig. 9.

The pressure of the atmosphere at the sea level is sufficient to force water up into a vacuum about 34 feet vertically; but owing to mechanical imperfections of pumps, the practical limit is 27 or 28 feet rise between the surface of the water and the valve of the pump. It is customary to use a force pump if water is to be raised to a height above this. Fig. 10.

Unlike water, air is not the result of a chemical union of two unlike simple gases. Nevertheless, air contains more than one substance. It is made up chiefly of two gases simply mixed together, and each exhibits its own characteristics to some extent.

Composition of Air

Pure air consists of oxygen, which we have found constitutes one-third of water, and of nitrogen (and argon). The oxygen forms about a fifth and the nitrogen four-fifths of the air. Besides these, several other gases are found in small but varying quantities.

To the oxygen gas is due the power of air to support combustion (fire) and life. Oxygen unites chemically with most other substances, and were the air all oxygen, the combustible part of the earth would soon be consumed by its own fires. Fortunately four-fifths of the air is a gas that has little power of combination and this nitrogen serves to dilute the oxygen and to weaken its force, much as water would dilute and weaken a strong and powerful chemical.

Nitrogen

The most marked characteristic of nitrogen is its sluggishness or inertness. Nitrogen, like oxygen, is a tasteless, odorless, colorless gas. It is fourteen

times as heavy as hydrogen. Though nitrogen from the air unites with other elements with difficulty, it is found in all living tissues, both animal and vegetable, and when these decompose the familiar substance, ammonia, is formed. This is a compound of hydrogen and nitrogen.

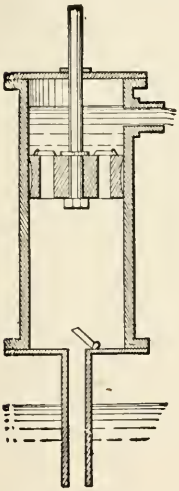


Fig. 9. Suction Pump.

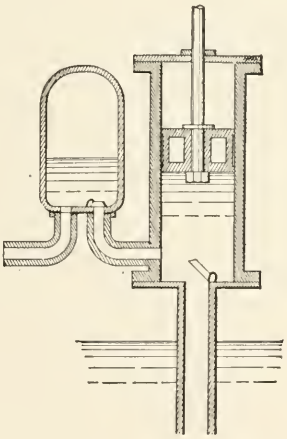


Fig. 10. Force Pump.

Carbon dioxide is always present in the atmosphere. This is one of the countless combinations of carbon, the element present in all animal and vegetable materials. Carbon is nearly pure in the form of charcoal. Soot, graphite or the black lead of lead pencils, and the

Carbon

diamond are other forms. Carbon unites very readily with oxygen and the gas formed by their chemical union is called carbon dioxide because it contains two parts of oxygen to one of carbon. Wood, coal, gas—almost everything that will burn in the air—and even our own bodies contain carbon, though we would not suspect its presence because it is combined with other substances and has merged its own character in those of the substances of which it forms a part. All our food contains carbon in its combinations.

Carbon Dioxide

When we breathe we take into our bodies the oxygen of the air. This oxygen is needed by the various organs and is carried in the blood from the lungs to all parts of the body. During the circulation the oxygen is taken up by the cells and replaced by carbon dioxide. This is brought back by the blood to the lungs and breathed out. If we remain long in a closed room, a portion of the oxygen of the air in the room and of the substance of our bodies is changed into carbon dioxide, which is unfit to breathe. This is the reason for the special need of ventilation in the sleeping room.

Water Vapor

Water in the form of vapor is constantly passing off into the air from the surface of bodies of water, from vegetation, and from animal organisms, as invisible vapor. The amount of water vapor present in the air is very variable. Warm air will hold more vapor than cold air. Ordinarily on a pleasant day, the atmosphere holds between 60 per cent and 70 per cent of the possible amount of water vapor.

Dew Point

When the air is saturated or at the dew point, a slight lowering of the temperature causes the vapor to condense. That air will absorb only a certain amount of moisture explains why a draft of air is necessary when drying clothes within doors and why the washing drys slowly on a damp day.

The presence of vapor in the air is shown by bringing a pitcher of ice water into a warm room. The air against the cold surface of the pitcher is cooled until the dew point is reached, when it deposits part of its moisture. Any person who wears glasses knows the effect of such condensation in going into a warm room from out of doors on a cold day. That the air exhaled contains water may be shown by breathing upon any bright, cold surface.

How a Chill is Produced

The discomfort we feel in a crowded room is largely due to the excess of moisture resulting from the breathing and perspiration of so many persons. The danger of going from a crowded reception or "tea" into the open air is also due to it. Crowded rooms become very warm, the air soon becomes saturated with vapor and cannot take away the perspiration from our bodies. Our clothes thus become moist and the skin tender. When we go into the colder, drier air, clothes and skin suddenly give up their load of moisture. Evaporation absorbs heat; the heat is taken from our bodies and a chill results. There is much to learn concerning the ventilation of rooms for social purposes.

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Argon

The air also contains a very small amount of a gas called argon. This was discovered in 1894. It resembles nitrogen so closely that it long escaped detection. Several other gases are present in minute quantities.

COMBUSTION

Very likely a fire must be built in the cook stove. In order that chemical combination may take place, the conditions must be right. The stove is so constructed that a current of air can pass from under the grate through the fire box, and funnel, to the chimney, and we must arrange that this air current shall not be unduly obstructed, for fuel will not burn without oxygen.

Kindling Point

Substances differ greatly as to the ease or difficulty with which they may be made to burn, or in chemical terms, with which they may be made to unite with oxygen. The temperature to which a substance must be heated before it will take fire is called the kindling point. We therefore place light materials, like shavings, pitch-pine chips, or paper on the grate, twisting the paper and arranging all in such a way that oxygen has free access to a large surface; upon this we place small sticks of wood, piling them across each other for the same reason, and on this, in turn, hard wood or coal. The large stick of wood or the coal cannot be kindled with a match, but the paper or shavings can, and these in burning will heat the wood until it takes fire which then will kindle the coal.

Chemistry of a Match

To kindle the fire, we unthinkingly light a match. The burning of the match repeats the same principle we have described. The match is made by dipping the ends of small sticks of wood into melted sulphur, a substance more easily kindled than wood. When the sulphur is dried, the match is tipped with a preparation of phosphorus. Phosphorus has such a low kindling temperature that friction of the match against any rough surface heats it sufficiently to set it on fire. In burning, this sets fire to the sulphur and this, in turn, kindles the wood.

Products of Combustion

The products (substances formed) of the burning match are oxide of phosphorus, oxide of sulphur, and carbon dioxide and water from the carbon and hydrogen of the wood. As our coal fire burns, we have two different oxides of carbon formed—carbon monoxide composed of one part carbon and one part oxygen, and carbon dioxide having two parts oxygen to one of carbon. The carbon monoxide formed in the lower part of the fire rises through the burning coals, takes up more oxygen at the top of the fire and forms carbon dioxide. The blue flames seen over a hard coal fire are caused by carbon monoxide burning. Carbon dioxide does not burn, since in this form the carbon holds as much oxygen as possible. The drafts and dampers so regulate the supply of oxygen that the fire may burn rapidly or slowly and that the harmful products of combustion may be carried out of the house by way of the chimney.

Carbon Monoxide

Constant Composition of the Air

It might be thought that with the millions of human beings and animals and countless fires constantly using oxygen and giving off carbon dioxide, that the atmosphere would soon consist of a large proportion of carbon dioxide. Nature has wonderfully provided for this. Carbon dioxide, which is the waste matter of animals, is one of the foods of plants. Thus the trees of the forest and the shrubs and plants of the garden are continually taking in the carbon dioxide and giving out pure oxygen, so that the carbon dioxide is kept at about three or four parts in 10,000 of air.

As has been said, wood consists mainly of the substances, carbon, oxygen, hydrogen, and nitrogen, together with other substances in small amounts. The growing tree has taken these simple substances from the air and earth and stored them up in a complex form as wood.

Elements

The chemist calls the simple substances out of which different things are made, elements. Carbon, oxygen, nitrogen, sulphur, phosphorus, silver, gold, copper, iron, lead, tin, mercury, zinc, aluminum are the chemical elements familiar to most people. When the wood is burned, or *oxidized*, its elements are made into new combinations, but in the burning no substance is *destroyed*. Some of the new products are invisible, it is true, but that they exist may be proved in many ways.

One of the fundamental laws of chemistry is the Law of Conservation of Matter (substance). This may be stated as follows: The weight of all the

products made in a chemical action is exactly equal to the weight of all the substances used. That is, the weight of the dry wood plus the weight of the oxygen required to burn it, equals the combined weight of carbon dioxide, water, and ashes produced. Matter can neither be destroyed nor created — it can only be changed or transformed. Scientists have reason to believe that there is just the same amount of oxygen, nitrogen, sulphur, iron and of all the other elements in the universe at the present moment as there was at the beginning of things.

Conservation of Matter.

A familiar form of nearly pure carbon is charcoal. It is made by heating wood for a time with a very small amount of air. The volatile parts of the wood are driven off, leaving the carbon. The old fashioned method of making charcoal is shown in Fig. 11, where the burning of part of the wood gave the heat necessary for the making of the charcoal. At the present time, most charcoal is made by the destructive distillation of hard wood in iron stills; the products being charcoal, crude wood alcohol, crude acetic acid, together with gas and wood tar, which last are burned to give the heat for the process.

Charcoal

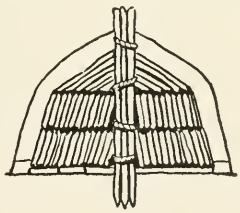

Fig. 11. Charcoal Kiln.

Charcoal is a porous substance and has the power of absorbing into its pores gases and even particles of

coloring matter. A few pieces of charcoal added to the water in which flowers are standing, or plants growing, help to keep the water sweet by absorbing the impurities. Boneblack, a very finely powdered animal charcoal, is used to decolorize liquids. If it is mixed with a dark syrup, for instance, and the mixture violently shaken, the color will be absorbed and filtration will give a nearly colorless syrup.

Coal

Coal is formed in almost every country on the earth, but the United States has the largest amount. It was originally wood and other carbonaceous material, once a part of living organism at a date of perhaps millions of years ago. During these years, the earth's crust has been subjected to slow upheavals and depressions, so that in some places, what was originally at the surface has been covered with thousands of feet of earthy matter, or possibly by the ocean. Under enormous pressure, the plants have been subjected to heat from the earth's interior. This is destructive distillation on the largest scale.

Graphite

In the making of coal if this distillation is complete, a substance called graphite is obtained. Graphite is the black lead used in lead pencils and in stove polish. It is a shiny, black mineral with a slippery feeling and is nearly 100 per cent carbon. If the distillation is less complete, hard coal, called anthracite containing about 90 per cent carbon, results. If still less perfect, soft or bituminous coal, having varying percentages of carbon, is formed.

Peat

Where the process goes on under water, peat is found. This is partially formed coal, but little distilled and contains only about 40 per cent carbon.

Besides carbon, these substances are made up of gases composed of carbon and hydrogen, called *hydro-carbons.* These gases give the yellowish and orange flames in a coal fire. Pure carbon does not burn with flame—it merely glows. Anthracite coal contains only from 3 to 4 per cent of volatile matter, but bituminous coal may have 30 to 40 per cent of these hydro-carbon gases.

Coke

Coke is made by the destructive distillation of soft coal. Like charcoal, it is chiefly carbon, but contains more mineral matter (ash). The coke obtained as a bi-product in the manufacture of coal gas is rather soft, but when coke is made as the principal product, it is hard and brittle. Coke makes a very hot fire without flame, but does not last as well as hard coal. The ash should be allowed to accumulate in the grate when burning it. Many consider it an improvement over soft coal for household use and it might be used to advantage more than it is.

Graphite is so hard and compact that it cannot be burned. Anthracite ignites with some difficulty and then burns slowly with intense heat.

Coking Coal

Bituminous coal ignites readily and burns well when there is sufficient draft. The "coking" variety cakes over on top and the fire must be broken up to allow the air to penetrate the fire. Soft coal should be put on the fire in small amounts as otherwise the hydro-

carbon gases escape unburned and thus much heat value is lost. Smoke is made up of finely divided particles of carbon and is always an indication of incomplete combustion and, therefore, loss.

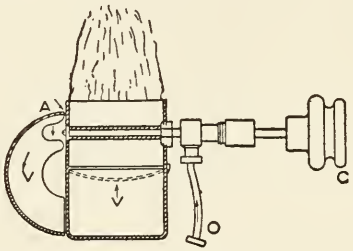

Fig. 12. Burner of a Blue Flame Oil Stove.

Oil from tank (not shown) is forced up O, is vaporized in passing through the straight tube, mixes with air at A, and burns with a blue flame at the top.

Kerosene

Kerosene and gasoline are also important fuels. Gas will be taken up under the subject of light. Petroleum is an oily liquid found in many places in large quantities, particularly in Pennsylvania and Ohio. It is made up almost entirely of compounds of carbon and hydrogen (hydro-carbons).

When the crude petroleum from the Pennsylvania district is purified by distillation and other processes, the main product is kerosene. The lighter and more volatile products are gasoline, naphtha, and benzine —all three having much the same composition. Gasoline is the most volatile. Among the heavier products are various lubricating oils, vaseline, and paraffin.

In order to burn, kerosene must be vaporized. In the new blue flame oil stoves, various devices are em-

ployed to vaporize the oil. In Fig. 12 the oil passes through a tube heated by the flame, where it is changed to vapor which is mixed automatically with air and is then burned. Sometimes an alcohol flame is used to start this process, but the flame of the burning oil itself continues it. A slight pressure of air is maintained in the oil reservoir to give a constant small jet of oil to be vaporized. In other styles of stoves, the oil is fed automatically by gravity to a hollow ring, when it becomes heated to the point that it gives vapor. The vapor mixes with air and burns with a blue flame. Fig. 13.

Blue Flame Oil Stoves

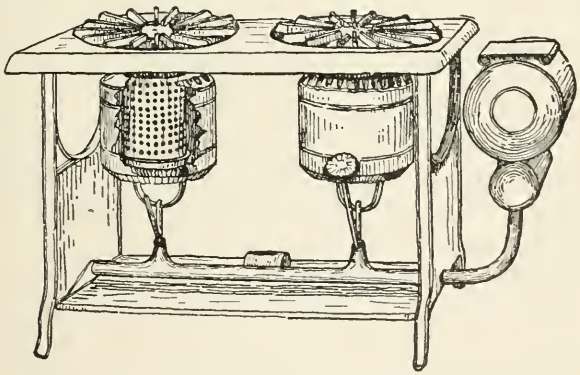

Fig. 13. Blue Flame Oil Stove, Showing Oil Reservoir and Lighting Ring.

Gasoline is burned on much the same principle as kerosene. It vaporizes much more easily and the pressure for the flow of the gasoline is furnished usually by having the tank a few feet above the burner.

Gasoline

Flash Point

The measure of safety of kerosene is the temperature at which it will give off an inflammable gas. This is called the *flash point* and is determined by heating the oil slowly and observing the temperature at which a flash can be produced by applying a lighted taper to the surface of the oil. Below the flash point, there is no danger of explosion from oil. Most states in the United States have a legal flash point, or a fire test, below which standard kerosene cannot be sold. The flash point of good kerosene is 120° F. The *fire test* is the temperature at which the oil will take fire and *burn* when a light is applied. This is about 30° F higher than the flash point. The ordinary temperature of the room is above the flash point of gasoline, naphtha, benzine, etc. In other words, these substances are constantly giving out an inflammable vapor.

Fuel Value

A comparison of the heating value of the various fuels will be of interest. Practical tests of the amount of steam produced in a steam boiler have shown that one cord of ordinary wood is approximately equal to one-half ton of coal; a gallon of oil (or gasoline) is equal to about twelve pounds of coal; 1,000 cubic feet of coal gas is equal to 50 or 60 pounds of coal, or about four and one-half gallons of oil. Hard coal has a little higher fuel value than soft coal, because the combustion is commonly more perfect. Coke is nearly equal to hard coal by weight, but is much more bulky. It is usually sold by measure. A bushel of coke weighs 40 pounds, of anthracite 67 pounds, and of soft

coal 76 pounds. Damp wood is a much poorer fuel than dry wood, because so much heat is absorbed and wasted in changing the water into steam.

The heat given off by a fuel is not the only point to be considered. In the cook stove, but a small portion of the heat given off by the solid fuel can be used for cooking, as most of it is radiated into the room or carried up the chimney. In the gas or oil stove, the flame may be applied exactly where it is wanted, so that the proportion of heat which can be used is much greater. Moreover, the flame can be shut off instantly when wanted no longer and all expense stopped. On the other hand, the range usually serves to heat the water of the hot water system, incinerate garbage, and in winter helps to heat the house.

FOOD

Having the fire well under way the housekeeper turns her attention to the breakfast. A great variety of chemical actions may here be considered. In the first place, why must we "eat to live?"

Why We Must Eat

Wherever there is life, there is chemical change; and as a rule a certain degree of heat is necessary in order that chemical change may occur. Vegetation does not begin in the colder climates until the air becomes warmed by the heat of the spring. When the cold of winter comes upon the land vegetation ceases.

Since many animals live in temperatures in which plants would die, it is evident that they must have some

Combustion in the Body

source of heat in themselves. This is found in the union of the oxygen of the air breathed with carbonaceous matter eaten as food and the formation of carbon dioxide and water, just as in the combustion of wood or coal. Only instead of this union taking place in one spot and so rapidly as to be accompanied by light, as in the case of fire, it takes place slowly and continuously in each living cell. Nevertheless, the chemical reaction seems to be identical.

Vital Temperature

The heat of the human body must be maintained at 98.5° F—the vital temperature—the temperature necessary for the best performance of the normal functions. Any continued variation from this degree of heat indicates disease. Especially important is it that there be no considerable *lowering* of this temperature, for a fall of one degree is dangerous, since in that case the chemical changes necessary to the body cannot be carried out.

Air as Food

The slow combustion or oxidation of the carbon and hydrogen of food cannot take place without an abundance of oxygen ; hence the diet of the animal must include fresh air—a point not always considered.

The amount of oxygen in food by weight taken in daily is equal to the sum of all the other food elements. Except water, two-thirds of these foods consists of some form of starch or sugar—the so-called carbohydrates, in which the hydrogen and oxygen are found in the same proportion as in water.

The power to do mechanical work comes from the

combustion of fuel. The body is a living machine capable of doing work, raising weights, pulling loads, and the like. The animal body also requires fuel in order to do such work as thinking, talking, even worrying. For the present, then, we will say that food is necessary, (1) to preserve the vital temperature and (2) to enable the body-machine to do its work.

The Body a Machine

Suppose we begin our breakfast with fruit, say, an orange or a banana. Fruits are especially rich in sugars and these are composed of carbon, hydrogen, and oxygen. If sugar is placed upon a stove, it will melt and steam (water) will pass off into the air, leaving the black charcoal (carbon) on the stove. Moreover, sugars burn easily and fiercely. We shall get both heat and energy from our fruit. Within the body it will be changed into water and carbon dioxide. Fruits contain a large percentage of water; but the banana is capable of giving more energy and heat than the orange, because it has much less water and more sugar. Fruit loses in drying a large portion of its water, so that dried fruits contain a larger percentage of food materials than fresh fruits. For instance, raisins are 60 per cent grape sugar.

Fruit

Fruits consist of a loose net-work of a woody material holding the soft pulp and this woody fibre, called cellulose, is practically indigestible. Cooking softens this, making cooked fruits easier to digest.

Cellulose

SUGARS AND STARCHES.

At breakfast some sugar from the sugar bowl may be added to the fruit. Many people add sugar to the oatmeal or other cereal eaten, although it is often held by teachers of dietetics that this is not a good place to use it, for proper cooking and thorough mastication of the cereal will bring out a rich sweetness due to changes explained later. Country boys know how sweet a morsel is made by chewing raw grains, especially wheat. Possibly a glass of milk is taken at breakfast and this contains another kind of sugar—milk sugar—in about 5 per cent. Coffee and tea are usually sweetened, so that a considerable part of the breakfast may be of this class of foods—a quickly burning material giving heat and energy.

Cane Sugar

There are several different sugars recognized by chemists; these are cane sugar or *sucrose,* grape sugar or *glucose,* milk sugar or *lactose,* and fruit sugar or *levulose*. Cane sugar is obtained from the juices of many plants, notably sugar beets, sugar cane, the palm, and as maple sugar from the rock-maple trees. Molasses and brown sugar are obtained during the manufacture of white sugar from sugar cane. Cane sugar is composed of carbon, hydrogen, and oxygen in the proportion of twelve parts of carbon to eleven parts of water. When sugar is heated it is chemically changed, more or less, according to the degree of heat and the rapidity with which it parts with its water.

Heating it gradually, we obtain first straw colored barley sugar, then brown caramel, and finally black carbon.

Grape Sugar

Grape sugar is found in honey and in all ripe fruits. It consists of carbon, hydrogen, and oxygen in somewhat different proportions from what they occur in cane sugar. It appears on the outside of dried fruits, such as raisins. It is only two-fifths as sweet as cane sugar. Large quantities are manufactured from corn starch.

Milk Sugar

Milk sugar is similar to cane sugar in composition. It is obtained from the whey of milk. It is hard and gritty and not very sweet to taste. When milk sours, it is because this sugar is fermented and changed into lactic acid. The acid causes the milk to curdle.

Fruit Sugar

Fruit sugar or levulose occurs with glucose (grape sugar) in fruits. It is about as sweet as cane sugar but it does not crystallize.

A marked characteristic of all sugars is their solubility and all but the last are crystalline substances, that is, will form crystals.

Starch

At breakfast bread, toast, or some cereal like oatmeal or wheat, usually follows the fruit course. These foods are prepared from grains (seeds) and contain much nutriment in a condensed form. They supply the body with starch and some nitrogenous food. But the body cannot use starch as such. It must be changed into a form of sugar called *starch sugar,* or maltose. While we are following Mr. Glad-

stone's rule and chewing each mouthful of our toast twenty-five times, we will consider what starch is like and how it is made available for use.

Source of Starch

Starch is found in greater or less abundance in all plants and is laid up in large quantities in the seeds of many species. See Fig. 14. Rice is nearly pure starch; wheat and the other cereals contain sixty to seventy per cent of it. Some tubers, such as potatoes, contain it although in less quantity—ten to twenty per cent.

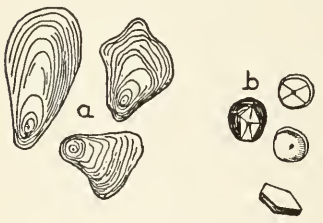

Fig. 14. Starch Much Magnified. a, Potato Starch; b, Corn Starch.

It is formed by means of the living plant-cell and the sun's rays, from the carbon dioxide and water contained in the air and it is the end of the plant-life — the stored energy of the summer. It is prepared and stored by the parent for the food for the young plant until the latter can start its own starch factories.

Starch in its common forms is insoluble in water. It dissolves partially in boiling water, forming a transparent jelly when cooled, as every housekeeper knows. The cellulose which occurs in various forms in the shells and skins of fruits, in their membraneous partitions, and in cell walls, is an allied substance.

DIGESTION

Digestion of Starch

Digestion is primarily synonymous with solution. All solid food materials must become practically soluble before they can pass through the walls of the digestive system. Starch and like materials must be transformed into soluble substances before absorption can take place. Cane-sugar, though soluble, has to undergo chemical change before it can be absorbed. By these changes it is converted into grape and fruit sugars. These and milk sugar are taken directly or with little change into the circulation. To this fact is due a large part of the great nutritive value of the dried fruits, as raisins, dates, and figs, and the advantage of milk-sugar over cane-sugar for children or invalids.

Under certain conditions—weakened digestive power or excess of sugar—cane-sugar may remain so long in the stomach before the change takes place that fermentation sets in and a "sour stomach" results. This is one of the dangers of too much candy.

The chemical transformations of starch and sugar have been very carefully and scientifically studied with reference to brewing and wine-making. Several of the operations concerned necessitate great precision in respect to temperature and length of time, and these operations bear a close resemblance to the process of bread-making by means of yeast.

Starch Conversion

There are two distinct means known to the chemist by which starch is changed to sugar. One is by the

use of acid and heat, which changes the starch into sugar, but can go no farther. The other is by the use of a class of substances called ferments, some of which have the power of changing starch into sugar, and others of changing the sugar into alcohol and carbon dioxide. These ferments are in great variety; some are always present in the air. Some are living plants, like yeast, Fig. 15, and others are chemical substances.

Ferments

Among the chemical ferments, one is formed in sprouting grain, which is called diastase or starch converter, and under the influence of warmth, changes the starch into a sugar. The starch first takes up water; then under the influence of the ferment, is changed into maltose, a form of sugar which can be directly absorbed into the circulation. A similar process is carried on in the preparation of malted foods.

Fig. 15.
Yeast Highly Magnified.

Conversion in the Body

The same cycle of chemical changes goes on in the human body when starchy substances are taken as food. Such food, moistened with saliva, and warmed in the mouth, becomes mixed with air through mastication. It thereby becomes impregnated with *ptyalin*, a ferment in the saliva, which can change starch into sugar, as can the diastase of the malt. The mass then passes into the stomach and the change, once begun, goes on. As soon as the sugar is formed, it is absorbed into the circulatory system and by the life proc-

esses, is oxidized, that is, united with more oxygen and changed finally into carbon dioxide and water, from which it was made by the help of plant life and sun light.

Digestion of Starch

No starch is utilized in the human system as starch. It must undergo transformation before it can be absorbed. Therefore, starchy foods must not be given to children before the secretion of the starch converting ferments has begun, nor to any one in any disease where the normal action of the glands secreting these ferments is interrupted. Whatever starch passes out of the stomach unchanged, meets with a very active converter in the intestinal juice. If grains of starch escape these two agents, they leave the system in the same form as that in which they entered it.

COOKING

Early man, probably, lived much like the beasts, taking his food in a raw state. Civilized man requires much of the raw material to be changed by the action of heat into substances more palatable and already partly digested.

Cooking of Starch

The chemistry of cooking the raw materials is very simple. It is in the mixing of incongruous materials in one dish or one meal that complications arise.

The cooking of starch, as rice, farina, etc., requires little explanation. The starch grains are prepared by the plant to keep during a season of cold or drought and are very close and compact; they need to be

swollen and distended by moisture in order that the chemical change may take place readily. Starch grains may increase to twenty-five times their bulk by absorbing water.

The cooking of the potato and other starch-containing vegetables, although largely a physical or mechanical process is very necessary as a preparation for the chemical actions of digestion; for raw starch has been shown to require a far longer time and more digestive power than cooked starch. Change takes place slowly, even with thorough mastication, unless the starch is swollen and heated, and, in case the intestinal secretion is disturbed, the starch may not become converted at all.

Bread

Our breakfast will undoubtedly contain bread. Bread of some kind has been used by mankind from the first dawn of civilization. During the earlier stages it consisted chiefly of powdered meal and water baked in the sun or on hot stones. This kind of bread had the same characteristics as the modern sea-biscuit, crackers, and hoe cakes, as far as digestibility was concerned. It had great density; it was difficult to masticate; and the starch in it presented but little more surface to the digestive fluids than that in the hard compact grain, the seed of the plant.

Experience must have taught the semi-civilized man that a light porous loaf was more digestible than a dense one. Probably some dough was accidentally left exposed; yeast plants settled upon it from the air;

fermentation set in, and the possibility of porous bread was thus suggested.

Ideal Bread

A light, spongy, crisp bread with a sweet, pleasant taste, is not only aesthetically but chemically considered the best form in which starch can be presented to the digestive organs. The porous condition is desired in order that as large a surface as possible may be presented to the action of the chemical converter, the ptyalin of the saliva, and later to other digestive ferments. There is also better aeration during the process of mastication.

Leaven or Yeast

Very early in the history of the human race, leavened bread seems to have been used. This was made by allowing flour and water to stand in a warm place until fermentation had well set in. A portion of this dough was used to start the process anew in fresh portions of flour and water. This kind of bread had to be made with great care, for germs different from yeast might get in, forming lactic acid—the acid of sour milk—and other substances unpleasant to the taste and harmful to the digestion.

A sponge made from perfectly pure yeast and kept pure may stand for a long time after it is ready for the oven and still show no signs of sourness.

On account of the disagreeable taste of leaven and because of the possibility that the dough might reach the stage of putrid fermentation, chemists and physicians sought for some other means of rendering the bread light and porous. The search began almost as

soon as chemistry was worthy the name of a science, and one of the early patents bears the date 1873. Much time and thought have been devoted to the perfecting of unfermented bread; but since the process of beer-making has been universally introduced, yeast has been readily obtained, and is an effectual means of giving to the bread a porous character and a pleasant taste. Since the chemistry of the yeast fermentation has been better understood, a change of opinions has come about, and nearly all scientific and medical men now recommend fermented bread, if well baked.

Chemistry of Bread-Making

The chemical reactions concerned in bread-making are similar to those in beer-making. To the flour and warmed water is added yeast, a microscopic plant, capable of causing the alcoholic fermentation. The yeast begins to act at once, but slowly; more rapidly if sugar has been added and the dough is a semi-fluid. Without the addition of sugar no change is evident to the eye for some hours, as the fermentation of starch to sugar by the diastase, gives rise to no gaseous products. The sugar is decomposed by the yeast plant into alcohol and the gas, carbon dioxide; the latter product makes itself known by the swelling of the whole mass and the bubbles which appear on the surface.

It is the carbon dioxide, which causes the sponge-like condition of the loaf by reason of the peculiar tenacity of the gluten, one of the constituents of wheat. It is a well-known fact that no other kind of grain will

make so light a bread as wheat. It is the right proportion of gluten (a nitrogenous substance to be considered later) which enables the light loaf to be made of wheat flour.

The production of carbon dioxide is the end of the *chemical* process. The rest is purely mechanical.

Object of Baking

The baking of the loaf has for its object to kill the ferment, to heat the starch sufficiently to render it easily soluble, to expand the carbon dioxide and drive off the alcohol, to stiffen the gluten, and to make chemical changes which shall give a pleasant flavor to the crust. The oven must be hot enough to raise the temperature of the *inside* of the loaf to 212° F, or the bacteria will not all be killed. A pound loaf, four inches by four inches by nine inches long, may be baked three-quarters of an hour in an oven where the temperature is 400° F, or for an hour and a half, when the temperature during the time does not rise above 350° F. Quick baking gives a white loaf, because the starch has undergone but little change. The long, slow baking gives a yellow tint, with the desirable nutty flavor, and crisp crust. Different flavors in bread are supposed to be caused by the different varieties of yeast used or by bacteria, which are present in all doughs, as ordinarily prepared.

The Crust

The brown coloration of the crust, which gives a peculiar flavor to the loaf, is caused by the formation of substances analogous to dextrine and caramel, due to the high heat to which the starch is subjected.

One hundred pounds of flour are said to make from 126 to 150 pounds of bread. This increase of weight is due to the incorporation of water, possibly by a chemical union, as the water does not dry out of a loaf, as it does out of a sponge. The bread seems moist when first taken from the oven, and dry after standing some hours, but the weight will be found to be nearly the same. It is this probable chemical change which makes the difference, to delicate stomachs, between fresh bread and stale. A thick loaf is best when eaten after it is twenty-four hours old, although it is said to be "done" when ten hours have passed. Thin biscuit do not show the same ill effects when eaten hot.

The bread must be well baked in any case, in order that the process of fermentation may be stopped. If this be stopped and the mastication be thorough, so that the bread when swallowed is in finely divided portions instead of in a mass or ball, the digestibility of fresh and stale bread is about the same.

Water Bread

The expansion of water or ice into more than seventeen hundred times its volume of steam is sometimes taken advantage of in making snow-bread, water-gems, etc. It plays a part in the lightening of pastry and crackers.

Air, at 70 degrees, doubles its volume at a temperature of 560 degrees F, so that if air is entangled in a mass of dough, it gives a certain lightness when the whole is baked. This is the cause of the sponginess of cakes made with eggs. The viscous albumen or

"white of egg" catches the air and holds it, even when it is expanded, unless the oven is too hot, when the sudden expansion is liable to burst the bubbles and the cake falls.

FATS

If cream instead of milk is used on the cereal or in the coffee, this with the butter on the bread, will add a considerable amount of another important food, fat. Fats form a large class of food stuffs which include the animal fats like cream, butter, suet, lard, cod liver oil and tallow, and vegetable fats like olive and cotton-seed oils, etc. Within the animal body all fats are liquids, being held in little cells which make up the fatty tissue.

Digestion of Fats

The digestion of fats is probably something like a process of soap making. With the intestinal fluids, the bile especially, the fats form an emulsion in which the globules are finely divided, and in some way are rendered capable of passing through the membranes into the circulatory system. The change, if any, does not destroy the properties of the fatty matters.

If we define cooking as the application of heat, then whatever we do to fats in the line of cooking is liable to hinder rather than help digestibility.

Cooking of Fats

Fats may be heated to a temperature far above that of boiling water without showing any change; but there comes a point, different for each fat, where reactions take place, the products of which irritate the mucous membranes and therefore interfere with diges-

tion. It is the volatile products of such decomposition which cause the familiar action upon the eyes and throat during the process of frying, and also, the tell-tale odors throughout the house. The indigestibility of fatty foods, or foods cooked in fat, is due to these harmful substances produced by too high temperature.

Composition of Fats

Many fats are solid at ordinary temperatures, while others are always liquids, but all fatty materials have a similar composition. When pure they contain only carbon, hydrogen, and oxygen. They differ from starch and sugar in the proportion of oxygen to the carbon and hydrogen, there being very little oxygen relatively in fats, hence more must be taken from the air for their combustion. If persons eat much fat they must have more fresh air to burn it. A person confined to the house needs to be careful what fats, and how much, are taken.

Heat from Fats

One pound of starch requires one and two-tenths pounds of oxygen, while one pound of suet requires about three pounds of oxygen for perfect combustion. This combustion of oxygen with the large amount of hydrogen, as well as with the carbon, results in a greater quantity of heat from fat, pound for pound, than can be obtained from starch or sugar. Experiments indicate that the fats yield more than twice as much heat as the carbohydrates; hence people in Arctic regions use large amounts of fat and everywhere the diet of winter may safely contain more fat than that of summer.

Food a Source of Energy

Both fats and carbohydrates are the sources of the energy or work done by the body as well as the heat to keep up the vital temperature and they must be increased in proportion as the mechanical work of the body increases. A man breaking stone needs more fat or starch than the student. If a quantity is taken at any one time greater than the body needs for immediate work, the surplus will be deposited as fat, and this will be drawn in case of a lack in the future supply of either; it is like a bank account.

NITROGENOUS FOODS

The animal body is more than a machine. It requires fuel to enable it not only to work but also to live, even without working. About one-third of the food eaten goes to maintain life, for while the inanimate machine is sent periodically to the repair-shop, the living machine must do its own repairing, day by day and minute by minute.

The adult animal lives, repairs waste, and does work; while the young animal does all these and more —it grows. For growth and repairs something else is needed beside starch and fat.

Nitrogen Necessary

The muscles are the instruments of motion, and they must be nourished in order that they may have power. The nourishment is carried to them by the blood in which, as well as in muscular tissue, there is found a food element which we have not heretofore considered, namely, nitrogen. It has been proved that the use of the muscles and the brain sets free certain

nitrogenous compounds which pass out of the system as such, and this loss must be supplied by the use of some kind of food which contains nitrogen. Starch and fat do not contain this element; therefore they cannot furnish it to the blood.

The American breakfast will probably include meat, fish, or eggs. These are examples of the nitrogenous food-stuffs. Nitrogenous food compounds are sometimes classed together under the name of proteins. These may be divided into proteids, gelatinoids, and extractives.

Proteids

The proteids all resemble albumin, which is found nearly pure in the white of an egg. These in some form are never absent from animal and vegetable organisms. They are most abundant in animal flesh and in the blood. Other common articles of diet belonging to this group in addition to albumin, are the curd of milk (casein), the lean of animal flesh and fish and gluten of wheat, and the legumin of peas and beans. The proteids are the most important nitrogenous food materials. They build up and repair the muscles, tendons, cartilage, bones, and skin and supply the albumin of the blood and other fluids of the body.

Gelatinoids

The animal skeleton—horns, bones, cartilage, connective tissues, etc.—contains nitrogenous compounds which are converted by boiling into substances that form with water a jelly-like mass. These are known as the gelatinoids and are so named because of their resemblance to gelatin. Although somewhat

similar to the proteids in composition they are not thought to be true flesh formers. However, they do help out the proteids in some unknown way.

Collagen

The chief constituent of the connective tissues of meats is *collagen*. This is insoluble in cold water, but in hot water becomes soluble and yields gelatin. Collagen swells when heated and when treated with dilute acids. Steak increases in bulk when placed over the coals, and tough meat is rendered tender by soaking in vinegar. Meat a few days old is tough, for the collagen is dry and hard. In time it becomes softened by acids which are secreted by bacteria either in or on the meat; the meat thus becomes tender and easily masticated. Tannic acid has the opposite effect upon collagen, hardening and shrinking it. This effect is taken advantage of in tanning, and is the disadvantage of *boiled* tea as a beverage, since tea always contains a little of this tannic acid when freshly made and much more if the tea is boiled.

Extractives

The last class of nitrogenous compounds are the extractives, so called because they are readily extracted by water from meat where they principally occur. The proteins of this class are thought to have little value as food, but they give the flavor to meats, etc., and are therefore of great importance. They are stimulants, somewhat of the nature of caffein of coffee and the thein of tea.

COOKING OF NITROGENOUS FOOD-STUFFS.

Cooking should render nitrogenous food more soluble because here, as in every case, digestibility means solubility. Egg albumin is soluble in cold water, but coagulates at about 160° F. At this point it is tender, jelly-like, and easily digested, while at a higher temperature it becomes tough, hard and dissolves with difficulty. Therefore, when the white of egg (albumin), the curd of milk (casein), or the gluten of wheat are hardened by heat, a much longer time is required to effect solution.

Albumin

As previously stated, egg albumin is tender and jelly-like when heated from 160° F to 180° F. This fact should never be forgotten in the cooking of eggs. Raw eggs are easily digested and are rich in nutriment; when heated just enough to coagulate the albumin or "the white," their digestibility is not materially lessened; but when *boiled,* the albumin is rendered much less soluble.

To fry eggs, the fat must reach a temperature of 300° or over—far above that at which the albumin of the egg becomes tough, hard, and well-nigh insoluble.

There is much albumin in the blood, therefore the juices of meat extracted in cold water form a weak albuminous solution. If this be heated to the right temperature the albumin is coagulated and forms the "scum" which many a cook skims off and throws away. In doing this she wastes a portion of the nutriment.

Gluten

Experiments on the digestibility of gluten have proved that a high temperature largely decreases its solubility. Subjected to artificial digestion for the same length of time, nearly two and one-half times as much nitrogen was dissolved from the raw gluten as from that which had been baked.

When gluten is combined with starch, as in the cereals, the difficulties of correct cooking are many, for the heat which increases the digestibility of the starch decreases that of the gluten.

Experiment.- The gluten in wheat flour may be obtained as follows: Place half a cupful of flour in a muslin bag and knead under water. The starch will work out through the bag. After a time all the starch may be so separated. A brown, elastic, stringy mass remains in the muslin. This is gluten, the nitrogenous part of the flour.

Casein

The same principle of cooking applies to casein of milk, although to a less extent. There seems to be no doubt that boiling decreases its solubility, and consequently, its digestibility for persons of delicate digestive power.

Meat

The nitrogenous substances of meat consist of soluble albumin, chiefly in the blood and juices, the albuminoids of the fibres, the gelatinoids of the connecting tissues, and the extractives. The cooking should soften and loosen the connective tissue, so that the little bundle of fibre which contains the nutriment may fall apart easily when brought in contact with the

teeth. Any process which toughens and hardens the meat should be avoided.

When it is desired to retain the juices within the meat or fish, it should be placed in boiling water so that the albumin of the surface may be hardened and prevent the escape of the albumin of the interior. The temperature should then be lowered and kept between 160 and 180 degrees during the time needed for the complete breaking down of the connective tissues.

Broth and Soup

When the nutriment is to be used in broths, stews, or soups, the meat should be placed in cold water, heating very slowly and the temperature not allowed to rise above 180° F until the extraction is complete. The extracted meat still retains the greater part of its original proteid substances. It is tasteless and uninviting, but when combined with vegetables and flavoring materials may be made into a palatable and nutritious food.

Effect of Temperature on Meat

Experiment. To show the effect of water at different temperatures upon raw meat, place a bit of lean meat about as large as the finger in a glass of cold water and let it stand an hour. The water becomes red, and the meat grows white. Pour off this water and boil it. A scum rises to the surface. The albumin dissolved has been rendered insoluble by heat.

Put a bit of raw meat into boiling water, and boil it hard several minutes. The meat is toughened by the process. The outside of the meat is hardened first, and very little of the nutriment dissolves in the water.

Put the meat into cold water and bring the temperature slowly to the boiling point; then allow it to simmer gently for some time. The meat is tender, and some of the nutriment is in the water. This is the method employed in making a stew. A little fat which is always present even between the fibre of the lean meat will be melted out and rise to the top of the water.

Digestion of Proteids

We have seen that the ferment in the saliva changed the starch into grape sugar. The ferment in the gastric juice, pepsin, with the help of an acid (principally hydrochloric acid) changes the albuminoids into peptones in the stomach. This change is completed in the intestines. The peptones are soluble in water and are absorbed into the blood.

SUMMARY OF THE EFFECTS OF COOKING

The object of all cooking is to make the food-stuffs more palatable or more digestible, or both combined. In general, the starchy foods are rendered more digestible by cooking; the albuminous and fatty foods less digestible. The appetite of civilized man craves and custom encourages the putting together of raw materials of such diverse chemical composition that the processes of cooking are also made complex.

Bread—the staff of life—requires a high degree of heat to kill the plant-life, and long baking to prepare the starch for solution; while, by the same process, the gluten is made less soluble. Fats, alone, are easily digested, but in the ordinary method of frying, they

not only may become decomposed themselves, and therefore injurious; but they also prevent the necessary action of heat, or of the digestive ferments upon the starchy materials with which the fats are mixed.

The effects of cooking upon the solubility of the three important food-principles may be broadly stated thus:

Effect on Solubility

Starchy foods are made more soluble by long cooking at moderate temperatures or by heat high enough to change a portion of the starch to dextrine, as in the brown crust of bread.

Nitrogenous foods. The animal and vegetable albumins are made less soluble by heat; the gelatinoids more soluble.

Fats are readily absorbed in their natural condition, but are decomposed at very high temperatures and their products become irritants.

MINERAL MATTER

The remaining ingredient of the food of our breakfast to be considered is the mineral matter which constitutes the ash when food-products are burned. There is only 5 or 6 per cent of mineral elements in our bodies, but these materials are necessary to life and health. They are found chiefly in the bones and teeth, but are present also in the flesh, blood, and other fluids. Phosphate of calcium forms the principal mineral part of the bones.

Common Salt

The food we eat contains a small amount of mineral matter which forms the ashes when food is burned.

This mineral matter gives the body the mineral salts which it needs; but in addition to this, most people desire and eat a considerable quantity of common salt every day. The amount eaten is far in excess of the sodium and chlorine the body requires, though sodium is an important constituent of many of the fluids of the body, and chlorine is found in hydrochloric acid of the gastric juice, the digestive fluid of the stomach. A great diversity of opinion exists as to the desirability of much salt in the diet, but the balance of evidence indicates that a liberal amount of salt is not harmful, but rather beneficial.

Experiment. To show the mineral part of bones, place a moderate sized bone on a hot coal fire for half an hour or longer.

To show the gelatinoids of bones, place a small bone in a shallow dish and cover with strong vinegar or weak hydrochloric acid (muriatic acid) and let stand over night or longer. The acid will dissolve out the phosphate of calcium leaving the animal matter.

Flavor Production

Coffee, an important part of the breakfast to most people, introduces an important feature of the chemistry of cooking—the production of the proper flavor. The chemical changes involved are too subtile for explanation here—indeed many are not understood. The change in the coffee berry by roasting is a familiar illustration. The heat of the fire causes the breaking up of a substance existing in the berry, and the formation of several new ones. If the heat is not sufficient,

the right odor will not be given; if it is too great, the aroma will be dissipated into the air, or the compound will be destroyed.

Broiling steak is another illustration—a few seconds too long, a few degrees too hot, and the delicate morsel becomes an irritating mass. The chemistry of flavor-producing is the application of heat to the food material in such a way as to bring about the right changes and *only* these. Flavors in addition to the pleasure they give to eating have the advantage of stimulating the flow of digestive fluids and making digestion more easy.

DECAY

The clearing away of the breakfast introduces to the housekeeper two important problems:—(1) the preservation of the remaining food from decay; (2) the proper cleaning of the articles used during the meal and its preparation.

Decay is caused by minute vegetable organisms known as moulds and bacteria. Both are present in the air either as the plants themselves or as their spores, the reproductive cells, ready to grow whenever they fall upon suitable soil. When these grow upon animal or vegetable substances, a variety of new compounds are formed, many of them taking oxygen from the air, so that finally the carbon becomes carbon dioxide, the hydrogen is oxydized to form water, and the other elements in their turn also become oxides, so that the decaying substance is utterly destroyed and

new substances made in its place. When organic substances are protected from the action of these living plants, decay will not ensue.

Decay Not Caused by Oxygen Alone

The old idea was that oxygen caused decay, but many experiments disprove this. Oxygen alone does not produce this result, but oxygen with "germs" will do so. These "germs" develop much more slowly in the cold, so that food is placed in the refrigerator or in a cool place and away from the dust.

The problems introduced by these living plants, their life history and their work, as well as the methods of prevention and care against their ravages, belong rather to household bacteriology than to chemistry. We are ready therefore to pass on to our next problem, that of cleaning.

UNIVERSITY OF CALIFORNIA

TEST QUESTIONS

The following questions constitute the "written recitation" which the regular members of the A. S. H. E. answer in writing and send in for the correction and comment of the instructor. They are intended to emphasize and fix in the memory the most important points in the lesson.

CHEMISTRY OF THE HOUSEHOLD.

PART I.

Read Carefully. Place your name and address on the first sheet of the test. Use a light grade of paper and write on one side of the sheet only. *Do not copy answers from the lesson paper.* Use your own words, so that your instructor may know that you understand the subject. Read the lesson paper a number of times before attempting to answer the questions.

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1. What do you understand a "chemical element" to be? Name all that you have ever seen.
2. What is a "saturated solution?"
   Name the substances usually found in the house which are soluble in water.
3. What causes atmospheric pressure? Explain some effects of it.
4. Why must the diet of animals include fresh air?
5. How do the hydro-carbons differ from the carbohydrates? Name some of each.
6. What are the products of combustion in burning coal or wood?
7. What is meant by "conservation of matter?"
8. How can the boiling point of water be raised? How may it be lowered?

9. What is meant when it is said that a chemical substance always has the same composition?
10. What is "latent heat?"
11. What can you say of the composition of meat?
12. Explain the physical and chemical changes which starch must undergo before it is absorbed into the circulation.
13. What can you say of the chemistry of bread-making?
14. Why is distilled water pure?
15. Explain the composition of water.
16. Describe the chemistry of a sulphur match.
17. How is charcoal prepared? How is coke made?
18. Why does the proportion of carbon dioxide in the atmosphere not increase?
19. In what different ways is food used in the body?
20. Do you understand all parts of this lesson paper? If not, what part is not clear?

NOTE.—After completing the test sign your full name.

CHEMISTRY OF THE HOUSEHOLD

A Day's Chemistry

PART II.

CLEANING

The cleaning of the dishes, silver, cutlery, and linen introduces a great variety of chemical problems. The subject of the chemistry of cleaning may well include with the daily task of dishwashing, the equally important ones of house cleaning and laundry work.

The various processes of housework give rise to many volatile substances, such as the vapor of water or fat. If not carried out of the house in their vaporous state these cool and settle upon all exposed surfaces, whether walls, furniture, or fabrics. This thin film entangles and holds the dust, clouding and soiling with a layer more or less visible everything within the house. The fires and lights give out smoky deposits of incomplete combustion. The dishes are soiled with waste from all kinds of foods—starch, grease, albumin, milk, gums, or gelatines and the juices of fruits.

Dust *alone* might be removed from most surfaces with a damp or even with a dry cloth, or from fabrics by vigorous shaking or brushing; but usually the greasy or sugary deposits must first be broken up and the dust thus set free. This must be accomplished without harm to the material which is dirty.

Cleaning, then, involves two processes: (1) the greasy or gummy film must be broken up, that the entangled dust and dirt may be set free; (2) the dust must be removed by mechanical means.

We will have occasion to use alkalis for cleaning and acids for removing stains and it will be well to consider what is meant by the terms, acid, alkali, and salt.

An Acid

An acid is a substance with an acid or sour taste and having the property of changing certain vegetable colors. A substance much used in testing for acids is *litmus,* a kind of fungus, giving a blue solution in water. Paper soaked in litmus solution and dried is known as test paper or litmus paper. It can be bought at any druggist's. This paper is turned red by the presence of any acid, even in the most minute quantity. An acid will cause effervescence with a carbonate like cooking soda or washing soda.

An Alkali

An alkali is a substance often having a soapy taste, a slippery feeling if strong, and the property of turning red litmus, blue.

Alkalies will neutralize the effects of acids. If an acid be added very carefully to an alkaline solution, there comes a point where the mixture will change the color of litmus in *neither* direction. The solution is neither acid nor alkaline, and is said to be *neutral.* If we make a weak solution of the acid sold at the drug stores as muriatic acid, and add to this very carefully a weak solution of caustic soda, until the solution is neutral, we shall find that the neutral solution

will taste like table salt. In fact, we have made common salt in this way.

A Salt

A chemical salt is a substance obtained by neutralizing an acid with an alkali or otherwise—a substance that is usually neutral and will turn the color of neither red nor blue litmus paper.

All acids contain the element hydrogen, which can often be driven out and replaced by a metal placed in the acid. If we drop a bit of zinc into some muriatic acid, tiny bubbles of hydrogen begin to escape. The zinc joins the remainder of the acid, making a new substance. This new substance is the metallic salt, called muriate (or chloride) of zinc. Muriatic acid is also called hydrochloric acid. Thus a salt results from neutralizing an acid with a metal. If oxide of zinc, a white powder, has been used in place of the metal, the same salt, chloride of zinc, would have been made; but no hydrogen gas would have come off, for the hydrogen of the acid would unite with oxygen of the oxide and form water.

Fats and Oils

Grease or fats, called oils when liquid at ordinary temperature, are chemical compounds made of carbon, oxygen, and hydrogen combined in many different ways, but all contain an ingredient of an acid nature known to the chemist as a fatty acid. The fatty acid base is combined with glycerine in the common fats.

Strong alkaline substances will break up fats into their parts and combine with the fatty acid, thus making soap.

Alkali Metals

The elements which form strong alkalis are the "alkali metals." The common elements of this group are sodium and potassium. There is also ammonium which is not an element, but a combination of nitrogen and hydrogen; it acts, however, like an alkali metal.

When an element unites with water in a certain way it is called a hydrate or hydroxide. The hydrate of ammonium—aqua ammonia or ammonia—is known as the "Volatile alkali" because it evaporates so easily. It is valuable for use in all cleansing operations—in the kitchen, the laundry, the bath, in the washing of delicate fabrics, and in other cases where its property of evaporation, without leaving any residue to attack the fabric or to absorb anything from the air, is invaluable.

Caustic Soda and Caustic Potash

The hydrates of potassium and sodium are called caustic potash and caustic soda, respectively, or the caustic alkalis or "lyes" because they "burn" animal tissues. These combine readily with fats to form compounds which we call soaps.

Most of the fats are soluble in turpentine, ether, chloroform, naphtha, or kerosene, and somewhat in alcohol. That is, the fats are dissolved unchanged, just as salt is taken up by water. These form solvents for greases more or less valuable according to conditions.

If the housekeeper's problem were the simple one of removing the grease alone, she would solve it by the free use of one of the solvents or by some of the strong

alkalis. This is what the painter does when he is called to repaint or to refinish; but the housewife wishes to preserve the finish or the fabric while she removes the dirt. She must, then, choose those materials which will dissolve or unite with the grease without injury to the article cleaned.

Soap

Soap is by all odds the safest and most useful cleaning agent. It is made from most of the common animal and vegetable fats and oils, as tallow, suet, lard, cotton seed oil and cocoanut oil, chemically combined with caustic soda or caustic potash. Castile soap is supposed to be made from olive oil. Rosin soap forms a part of all common yellow soap. It lessens the cost and makes a good soap for rough work. Silicate of soda is sometimes added to cheap soaps. It has some cleansing action, but must be regarded as an adulterant.

Good soaps are nearly neutral substances because the alkali has been neutralized by the fatty acid. The coarser grades may contain more or less free alkali. All soaps are slightly decomposed when dissolved in water. The freed fatty acid produces the milkiness seen when a cake of soap is placed in perfectly pure water.

Action of Soap

The cleaning action of soaps consists chiefly in forming emulsions with oily or greasy substances. Cream is an example of a very perfect emulsion. Its fat is in the shape of very finely divided globules and because of the whey which surrounds them, the cream can be mixed with a very large quantity of water and

show no sign of greasiness. When the whey is separated as in churning, the globules of fat come together and butter is formed. An emulsion is not a true solution, for the particles of fat can be separated by proper means from the liquid.

The soap makes an emulsion with the oily or greasy substances holding the dirt, so that both may be washed away by the water. A certain proportion of free alkali in soap helps the action, but it has a corrosive effect on many materials. Soap will form emulsions with many other materials besides fats and oils; so while water is a very general solvent, soap and water will take up many additional substances.

Kinds of Soap

The housekeeper may be familiar with two kinds of soap: hard soaps and soft soaps. Caustic soda makes the hard soaps and caustic potash makes the soft soaps.

Caustic potash is derived from wood ashes and a few generations ago soft soap was the only laundry soap used. Wood ashes were plenty when wood fires were universal. Soda-ash was at that time derived from sea weeds, and therefore uncommon inland. Early in the century a French manufacturer, Leblanc, discovered a process of making soda-ash from sodium chloride or common salt. This quite reversed the condition of the two alkalis, for now soda-ash is much more common, and the manufacture of soap on a large scale really began then. Soda-ash is now the cheapest form of alkali. Caustic soda is made from soda-ash.

Soda-Ash

The terms, soda-ash, and pot-ash have been used; these substances in chemical terms are respectively the carbonate of sodium and the carbonate of potassium. They are chemical compounds made up of carbonic acid and two metals—sodium and potassium. When the carbon dioxide, which we have seen is formed by the combustion of carbon, is added to water, carbonic acid results. This is a very weak acid and when it is combined with the very strongly alkaline elements, sodium or potassium, the result is an alkaline substance. Soda-ash and potash (sometimes called pearl-ash) are called alkalis, but they are not nearly so powerful as the hydrates of sodium and potassium which are commonly called caustic soda and caustic potash.

Washing Soda

When soda-ash, which is a white powder, is dissolved in hot water and the solution is cooled, crystals of the common washing soda are formed. This substance is also called "sal soda" and "soda crystals." The crystals contain about 65 per cent of water and when exposed to the air, lose some of this water and crumble to the white powder, soda-ash. The powder is, therefore, stronger than the original crystals.

Washing soda should never be used in a solid form, but should be dissolved in a separate dish, and the solution used with judgment. A satisfactory amount is about two ounces of the dry soda to a large tub of water, and well dissolved before the clothes are put in. Nearly all of the "washing compounds" on the market

depend upon the washing soda for their efficiency, and sometimes they contain nothing else.

Borax

Borax is a useful alkali, milder than washing soda, but effective as a cleaner, disinfectant, and bleacher. It is more expensive than either of the others described, and because of its weaker alkaline action, more of it must be used to produce a given result. It is much less irritating to the skin and less injurious to fabrics than soda, so for some uses its additional cost may be justified. Caustic potash or "lye" is too strong an alkali to use on fabrics, but is valuable to put down the kitchen sink drain to free it from grease. The soap made in the drain will be washed out by water. Solid washing soda may be used for the same purpose.

Hard Water

In the laundry the composition of water is important. Water for domestic use is either hard or soft, according as it contains a greater or less quantity of certain soluble salts—usually compounds of lime or magnesia, which have been taken up by the water while passing through the soil.

Temporary Hardness

When the hardness is caused by calcium carbonate (carbonate of *lime*) it is called "temporary" hardness, because it may be overcome by boiling. The excess of carbon dioxide is driven off and the carbonate of lime separates out. The same separation is accomplished by the addition of sal soda, borax, or ammonia.

Permanent Hardness

When the hardness is due to the sulphates and chlorides of magnesia or lime, it cannot be removed

by boiling. It is then known as "permanent" hardness. Public water supplies are sometimes softened before delivery to the consumer by the addition of slaked lime, which absorbs the carbon dioxide, and the previously dissolved carbonate separates out.

Soft water is needed in laundry work both for cleanness and economy, and water not naturally soft should be softened by boiling or by the addition of the before mentioned substances.

Soap and Hard Water

When soap is added to the hard water, it is decomposed by the water, and the new compound formed by the union of the lime and magnesia with the fatty acid of the soap is insoluble, and therefore settles upon any article with which it comes in contact. Until all the lime has been taken out, there will be no action between the soap and the dirt. Therefore, large quantities of soap must be wasted. It has been estimated that each grain of carbonate of lime per gallon causes an increased expenditure of two ounces of soap per 100 gallons, and that the increased expense for soap in a household of five persons where such hard water is used might amount to five or ten dollars yearly.

This "lime soap," although insoluble in water, will dissolve readily in kerosene or naphtha, for which reason, kerosene will be found very effective for cleaning bowls or the bath tub when the surface has become coated from the use of hard water and soap.

Cooking with Hard Water

Hard waters produce certain undesirable effects in cooking processes. The cooking of beans and similar

vegetables should soften the cellulose and break up the compact grains of starch. It is difficult to cook vegetables in hard water, for the legumin of the vegetable forms an insoluble compound with the lime or magnesia of the water, and the cellulose is softened with great difficulty. Hard water does not readily extract the flavor from tea and coffee, and therefore much more of either must be used to get the desired strength.

Dish Washing

During this discussion of cleansing agents, let us hope that the breakfast dishes have been soaking in water, after having carefully scraped or "scrapped" so as to save soap in washing and to keep the water as clean as possible. Plenty of hot water and soap with clean, dry towels is the secret of quick and easy work. If the hard water is used, it may be softened for the soap is doing no good unless there is a strong suds.

To save the appearance of the hands, use a good white soap, free from alkali, and soften the water with borax.

Glass, silver ware, china and kitchen ware take their turn. All should be rinsed in hot water to remove the soap and heat the dishes so that they will drain nearly dry and thus make wiping easy. In the dish washing machine used in large hotels and restaurants, the dishes are simply washed with soapy water and rinsed in very hot water while in such a position that

they drain perfectly. They dry completely and require no wiping. Fig. 16.

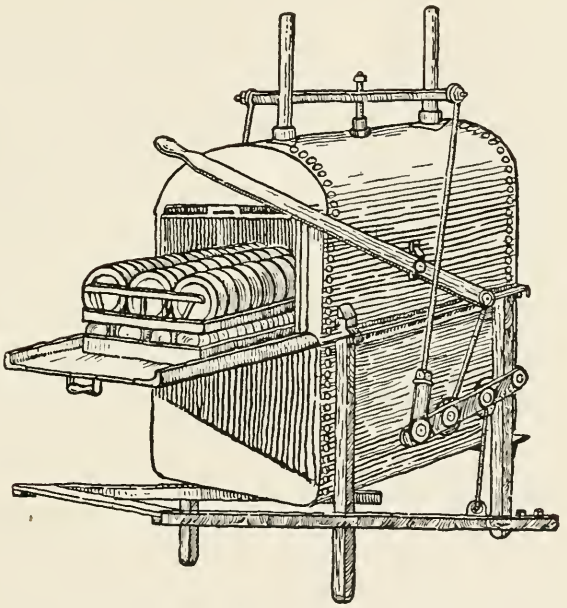

Fig. 16. Dish Washing Machine Used in Large Hotels and Restaurants.

Experiment. Wash a plate and dip it in very hot water, then place it so that all parts will drain. Observe if it dries completely. See if you can wash the dishes in this manner with very little wiping and if time would thus be saved.

CHEMISTRY OF THE LAUNDRY

If the morning happens to be Monday, the washing is probably in progress in the average American family. The mistress should understand the chemical principles involved and every detail of the work, in order that the best results may be secured, and that the clothes may not be harmed.

Structure of Fibres

The fibres of cotton, silk, and wool vary greatly in their structure and a knowledge of this structure as shown under the microscope, may guide to proper methods of treatment. Fig. 17.

Cotton

The fibres of cotton, though tubular, become much flattened during the process of manufacture, and under the microscope, show a characteristic twist, with the ends gradually tapering to a point. It is this twist, which makes them capable of being made into a firm, hard thread.

Wool

The wool fibre, like human hair, is marked by transverse divisions, and these divisions are serrated. These teeth become curled, knotted or tangled together by rubbing, by very hot water, or by strong alkalies. This causes shrinking, which should be prevented. When the two fibres are mixed, there is less opportunity for the little teeth to become entangled and therefore there is less shrinkage.

Linen

Linen fibres are much like cotton, with slight notches or joints along the walls. These notches serve to hold the fibres closely together, and enable them to be felted to form paper. Linen, then, will shrink, though

not so much as wool, for the fibres are more wiry and the teeth much shorter.

Silk fibres are perfectly smooth and when rubbed, simply slide over each other. This produces a slight shrinkage in the width of woven fabrics. **Silk**

Cotton and wool differ greatly in their resistance to the treatment of chemicals. Cotton is very little affected by a solution of the alkalies, when the cloth is well rinsed. If the alkali is not removed completely, however, it becomes very concentrated when the cloth dries, and as it generally acts for a long time, the fibre may be weakened or "tendered."

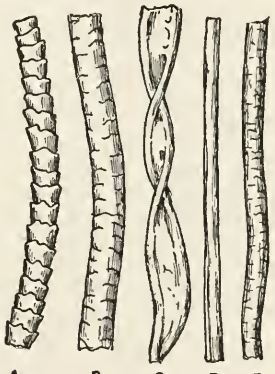

Fig. 17. Textile Fibres Much Magnified.
a, Wool; b, Mohair; C, Cotton; d, Silk; e, Linen.

Chemical Action on Fibres

Cold dilute solutions of the acids have no very great effect on cotton, provided always that they are completely washed out. Strong or hot solutions of acids have a very decided deleterious action, and even a very minute quantity of acid *dried* on the goods tenders the fibre badly.

Wool resists the acids well, but is much harmed by the action of the alkalies. A warm solution of caustic soda or caustic potash will dissolve wool quickly and completely. The carbonates, like washing soda,

have not such a decided effect, but they make the wool harsh and less flexible.

Linen resembles cotton and silk is much like wool in the resistance to chemical action, but the linen is more affected by the alkalies than cotton and silk is more acted on by acids than wool.

Fig. 18. Sections of Ordinary and Mercerized Cotton Fibres.

Mercerization

That cotton fibre is not seriously affected by alkalies is shown by the process of mercerization. In this process, patented by Mercer in 1852, the cotton threads are treated with a strong solution of caustic soda while under tension. The fibres lose their twisted and hollow shape and become more rod-like and nearly solid, as shown in Fig. 18. The threads have a tendency to shrink considerably, but are prevented by the tension. This and the method of manipulation gives the mercerized fabric the characteristic gloss somewhat resembling silk.

Soaking

In laundering, the best practice seems to be to soak the white clothes at least, in cold water or in luke-warm suds. The badly soiled portions may be soaped and rolled tightly to keep the soap where it is

most needed. The water should be well softened, and a very little extra washing soda solution may be added. The soaking loosens the dirt and saves much rubbing and hence wear on the clothes. It is probable that the cleansing wears out the articles which make up the weekly wash more than the actual use they receive.

Boiling

After washing the clothes, they may be wrung out and put into a boiler of cold water, which is then heated and boiled briskly for a little while. Whether to boil, or not to boil the clothes depends largely upon the purity of the materials used. If there is any iron in the water, or elsewhere, it is sure to be deposited on the goods, thus producing yellowness. Soap may be added to the clothes in the boiler, or borax may be used, allowing a tablespoonful to every gallon of water. The borax serves as a bleacher and as an aid in the disinfection of the clothes. One great advantage of boiling is the additional disinfection which this insures.

Rinsing

After washing, the clothes should be thoroughly rinsed. They cannot be clean otherwise and proper rinsing is essential to successful washing. The more thoroughly the wash water is removed between rinsings, the less number of rinsings will be required to give the same results.

Bluing

Bluing is frequently added to the last rinsing water to counteract, or cover up, any yellowness. A light blue appears to the eye whiter than a light yellow.

The color is, however, gray in comparison with white. Most of the liquid bluing now on the market contains Prussian Blue, a compound of iron. This compound is decomposed by soap and alkalies, when the goods are next washed, making a slight yellow stain of iron on the cloth. Frequent repetitions of this action may give a distinctly yellow shade to the white goods. The indigo blue used a generation or more ago did not have this objection. It is said that white goods which have never been blued, never require bluing.

Stains

Stains and all special deposits should be removed before the goods are treated with soap or soda, as these frequently set the stains. Hot water will spread any grease and also set many stains, so the clothes when not soaked, should be wet thoroughly in cold or luke-warm water before washing.

Washing Colored Goods

Colored goods and prints require more delicate treatment than white goods. If they are soaked, the water should be cold and contain very little soap and no soda. Only dissolved soap should be used in washing them, and this should be of good quality, free from alkali. They should be dried with the wrong side out and in the shade, for direct sunlight fades colors about twenty times as much as reflected light.

Washing Woolens

All wool goods require the greatest care in washing. The different waters used should be of the same temperature and never too hot to be borne comfortably by the hand.

Soap Solution

The soap used should be in the form of a thin soap solution. No soap should be rubbed on the fabric and only a good, white soap, free from rosin, is allowable. Make each water slightly soapy and leave a very little in the fabric at the end, to furnish a dressing as nearly like the original as possible.

Many persons prefer ammonia or borax in place of the soap. For pure white flannel, borax gives the best satisfaction on account of its bleaching quality. Whatever alkali is chosen, care should be exercised in the quantity taken. Only enough should be used to make the water very soft.

Brushing Woolens

The fibres of wool collect much dust upon their tooth-like projections and this should be thoroughly brushed or shaken off before the fabric is put into water. All friction should be by squeezing, not by rubbing. Wool should not be wrung by hand. Either run the fabric smoothly through a wringer or squeeze the water out, that the fibres may not be twisted. Wool may be well dried by rolling the article tightly in a thick dry towel or sheet and squeezing the whole till all moisture is absorbed. Wool should not be allowed to freeze, for the teeth will become knotted and hard. Above all, the drying should be accomplished quickly, and in short, the less time that is taken in washing, rinsing, and drying, the less will be the shrinkage and the better will be the result.

Starching

Some of the clothes are starched. This in addition to making them stiffer and giving them a better appearance helps to keep them clean longer. Household starch is usually made from potatoes or damaged flour. Corn starch has the greatest stiffening effect, wheat starch the next, and potato the lowest. Starch is either applied cold, using one of the prepared starches, or as boiled starch. The prepared starch is made slightly soluble and the grains are very fine so that they penetrate between the fibres. In making cooked starch, the starch should be wet with a little water and then the required quantity of boiling water may be poured on while stirring, after which the mixture may be boiled until clear.

It is necessary to have the goods dry for stiff starching for otherwise the starch solution would be too much diluted and also would not penetrate. In order to make boiled starch penetrate it is usual to clap the goods between the hands. The goods are rolled up for a while to equalize the distribution of the starch before ironing.

Uncooked Starch

As the uncooked starch depends upon the heat of the iron to swell and stiffen it, a hotter iron is required for good results with uncooked starch than with boiled starch.

For producing an ecru shade in curtains, coffee is sometimes added in quantity to give the desired color. A solution of gum arabic is sometimes used to stiffen

dark colored clothes which would show the white color of the starch.

THE REMOVAL OF STAIN

Whenever possible, stains should be removed when fresh. If the staining substance is allowed to dry on the cloth, its removal is always more difficult, and sometimes a neglected spot or stain cannot be removed without damage to the cloth.

Grease Spots

The nature of the spot must be known before the best substance to dissolve and remove it can be chosen. To remove grease spots, solvents of grease should be chosen, though we may remove such spots sometimes by causing the grease to form an emulsion with soap and thus be removed, or the grease may be made into a soap with ammonia or washing soda and thus dissolved and removed in water. The first of the three methods is, as a rule, the best. Grease will dissolve readily in benzine, naphtha, gasoline, kerosene, ether, and chloroform and somewhat in turpentine and hot alcohol. Ether and chloroform are the best solvents, but they are more expensive and not much more effective than naphtha.

Precautions

Caution! All of the solvents for grease are inflammable and some are explosive, so that they should never be used near a fire or light. Work with them should be done in the day time and preferably out of doors.

In applying any of these solvents to grease spots in fabrics, a cloth should be placed underneath the stain to absorb the excess of liquid containing the dissolved grease. The spot should be rubbed from the outside towards the center until dry. This will tend to distribute the solvent and prevent the formation of a ring where the liquid stops. It is well to apply the solvent on the wrong side of the fabric. Old spots of any kind may require long treatment. For this a little lard may be rubbed into the spot and left for some time, then the whole may be dissolved by naphtha or washed out with soap or ammonia.

Absorbents

Spots of grease on carpet or heavy material may be treated with absorbents. Heat will assist by melting the grease. Fresh grease spots may often be removed by placing over the spot a clean piece of blotting paper and pressing the spot with a warm iron. French chalk or whiting may be moistened with naphtha and spread over the spot. When all is dry, brush off the absorbent. The absorption method may be used in many other cases, moistening with cleansing agent which will not harm the material treated.

Bluing Stains

Bluing spots may frequently be removed by soaking in strong ammonia water. Alcohol or ammonia will remove grass stains, and an old remedy is to smear the stains with molasses before the article goes into the wash. The acids in the molasses seem to have the desired effect on the grass stains.

Coffee and Fruit Stains

Fresh stains of coffee, tea or fruit may be removed by hot water. Stretch the stained part over an earthen dish and pour boiling water upon the stain until it disappears. It is some times better to sprinkle the stain with borax and soak in cold water before applying the hot water. Old, neglected stains of coffee, fruits, cocoa, etc., will have to be treated with some bleaching agent. In many cases, it is not possible to remove them without severely damaging the cloth.

Mildew

Mildew causes a spot of a totally different character from any we have considered. It is a true mold, and like all plants, requires warmth and moisture for its growth. When this necessary moisture is furnished by any cloth in a warm place, the mildew grows upon the fibres. During the first stage of its growth, the mold may be removed, but in time, it destroys the fibres.

Strong soapsuds, a layer of soft soap, and pulverized chalk, or one of chalk and salt, are all effective if, in addition, the moistened cloth be subjected to strong sunlight, which kills the plant and bleaches the fibres. Bleaching powder or Javelle water may be tried in cases of advanced growth, but success cannot be assured.

Vaseline Sta

Some of the animal and vegetable oils may be taken out by soap and *cold* water or dissolved in naphtha, chloroform, ether, etc. Mineral oil stains are not soluble in any alkaline or acid solutions. Kerosene will

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evaporate in time. Vaseline stains should be soaked in kerosene before water and soap touch them.

Paint

Paints consist mainly of oils and some colored earth. Spots of paint, then, must be treated with something that will take out the oil, leaving the insoluble coloring matter to be brushed off. Turpentine is most generally useful.

Spots of varnish or pitch may be dissolved by the use of the same solvents as paint. Alcohol is also one of the best solvents here.

Spots made by food substances are greasy, sugary, or acid in their nature. Whatever takes out the grease will generally remove the substance united with it, as the blood in meat juices. Sugar is dissolved by hot water, so sticky spots are best removed with this.

Ink Spots

Ink spots are perhaps the worst that can be encountered, because of the great uncertainty of the composition of inks of the present day. When the character of an enemy is known, it is a comparatively simple matter to choose the weapons to be used against him, but an unknown enemy must be experimented upon and conquest is uncertain.

Indelible Ink

Indelible inks formerly owed their permanence to silver nitrate. Now many are made from aniline black solutions and are scarcely affected by any chemicals. The silver nitrate inks become dark in the sun by a photographic process. Many silver salts, and some salts of other metals, change in color in a bright light.

Silver nitrate inks may be removed by bleaching powder solutions. The chlorine in this replaces the nitric acid forming white silver chloride. This will darken if not at once removed, but will dissolve in strong ammonia water or a solution of hyposulphite of soda. This last salt, much used by photographers, commonly called "hypo," will often dissolve the stain of indelible ink without the use of the bleaching fluid and is less harmful to the fibres. Some inks contain carbon in the form of lamp black which is not affected by any chemicals which can be used.

Writing Ink

The old fashioned black ink is a compound called the gallo-tannate of iron. It is made by adding a solution of sulphate of iron to a water solution of nut galls. A little gum solution is added to make the ink of better consistency. This kind of ink is removed by the addition of a warm solution of oxalic acid or muriatic acid drop by drop, and this finally well rinsed out. Of course some materials will be injured by the acids, so this method must be used with caution. Lemon juice and salt will sometimes remove the spot and is safe. Cover the spot with salt, wet with lemon juice, and spread in the sun. Bleaching powder solution and acid will frequently destroy any ink stain of long standing which acids alone will not affect.

Some ink stains are removed when fresh by clear, cold, or tepid water—skimmed milk is safe and often effective. If the stain is allowed to soak in the milk

until the milk sours, the result is often better. Sometimes the ink will dissolve out if a piece of ice is laid on the spot and blotting paper under it. The blotting paper absorbs the water and should be often changed.

Ink on Carpets

Ink on heavy materials like carpets and draperies may be treated with some absorbent to keep the ink from spreading. Bits of blotting paper, cotton batting, meal, flour, sawdust, etc., may be used and removed as long as any ink is absorbed, then go over the spot repeatedly with a lemon freshly cut, and finally rinse with cold or tepid water. If an ink stain has worked through varnish into the wood, turpentine will usually remove the spot.

Colored Inks

Of late colored inks are generally prepared from aniline colors. These are made from substances produced in the distillation of coal tar. The colors are soluble in water, and by dissolving them and adding to the mixture some thickening substance, different colored inks are produced. They are rather difficult to remove successfully, but bleaching powder solution will frequently destroy them.

Iron Rust

The red iron-rust spots must be treated with acid. These are the results of oxidation—the union of the oxygen of the air with the iron in the presence of moisture. The oxide formed is deposited upon the fabric which furnishes the moisture. Ordinary "tin" utensils are made from iron coated with tin, which soon wears off, so no moist fabric should be left long in tin unless the surface is entire.

Removing Rust

Iron-rust is, then, an insoluble oxide of iron. The chloride of iron is soluble and so hydrochloric acid is used to remove the rust. The best method of applying the acid is as follows: Fill an earthen dish two-thirds full of hot water and stretch the stained cloth over this. Have near two other dishes with clear water in one and ammonia water in the other. The steam from the hot water will furnish the heat and moisture favorable for chemical action. Drop a little hydrochloric (muriatic) acid on the stain with a medi-

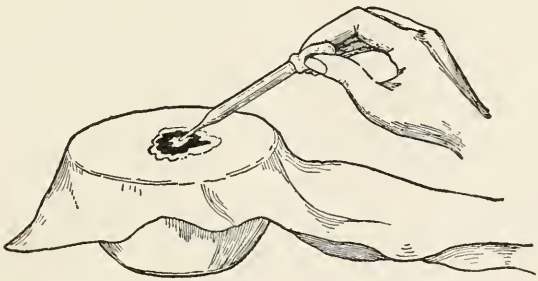

FIG. 19. REMOVING IRON RUST STAIN.

cine dropper. Fig. 19. Let it act a moment, then lower the cloth into the hot water. Repeat till the stain disappears. Rinse carefully in the clear water and, finally, immerse in the ammonia water, that any excess of acid may be neutralized and the fabric protected.

Salt and Lemon Juice

Salt and lemon juice are often sufficient for a slight stain, probably because a little hydrochloric acid is formed from their union.

Ink stains on colored goods are often impossible to take out without also removing part of the dye. The ink must be washed out in cold water *before* it dries; any slight stain remaining can, perhaps, be removed with a weak acid like lemon juice without harming the color.

BLEACHING

When the clothes are washed, the mistress likes to have them hang out of doors where the air and sunshine can dry them. She is glad when the white articles can be spread on the grass, knowing that they will be made whiter by Nature's bleaching agent. The sunlight is the chief agent in this bleaching and the articles are laid flat on the grass so that the rays of light will strike in a more perpendicular direction. There are also other devices for bleaching, among which are the fumes of burning sulphur, chloride of lime (bleaching powder) and Javelle water.

Originally all bleaching of linen and cotton was done out of doors by the action of oxygen, water, and sunlight. In these days of great factories, this process is impossible for lack of space; but various artificial bleaching stuffs have been discovered whose action is satisfactory if skilfully used.

Bleaching Powder

Chlorine is a gas which has remarkable readiness to combine with other bodies. It is even more energetic than oxygen. By its action upon them, chlorine destroys the greater number of coloring substances. Be-

cause of its harmful action upon the human body, chlorine gas itself cannot be used in factories or in the household, but the compound which chlorine forms with lime (oxide of calcium) known as *chloride of lime* or *bleaching powder,* is safe and effective.

Action of Chlorine

The principal coloring matters are composed chiefly of the elements carbon and hydrogen and some of the metals. If a substance which makes new combination with the elements present is brought in contact with these colors, the new compounds thus produced may be colorless. The element chlorine does just this. It can be set free from chloride of lime by weak acids, and will dissolve very readily in water when so set free. By dipping colored cloth into a weak solution of chloride of lime and acid, many colors and stains are at once destroyed. But the energy of the chlorine is not stopped by this process. Having destroyed the color, the bleaching powder attacks the fibres of the goods, unless the cloth is at once placed in some solution which can neutralize the bleaching powder. There are several such easily obtained and used. The use of bleaching powder in the household is frequently of dubious success for lack of this precaution. Ammonia water will perform this action satisfactorily, since the harmless soluble salt, ammonium chloride, is formed; hypo-sulphite of soda is also effective.

Chloride of Lime

Chloride of lime loses strength rapidly if exposed in an open vessel. It absorbs water and carbon di-

oxide from the air, grows damp and the chlorine gas escapes.

In using bleaching powder, mix one or two teaspoonfuls with a pint of cold water in an earthenware dish. The effective part of the powder will be dissolved, so let the mixture settle, or strain off the liquid through a cloth. Add a little vinegar or a few drops of acetic acid to the nearly clear solution and use at once.

Javelle Water

Javelle water is also used as a bleaching agent. It is very like bleaching powder, except that soda replaces the lime. It is prepared by dissolving one pound of washing soda in a quart of hot water and adding one quarter of a pound of chloride of lime also dissolved in a quart of hot water. Let the mixture settle, pour off the clear liquid and bottle it for use. It will keep for some time. The dregs may be used to scour the kitchen floor or to disinfect waste pipes. This is very useful in removing stains on white cloth, but the addition of some solution to neutralize the action is always necessary, just as with bleaching powder. The best substance to use for this is hypo-sulphite of soda, the "hypo" used in photography, which is quite harmless to the cloth.

Sulphur Dioxide Bleaching

Chlorine cannot be used in bleaching fabrics of animal fibre such as wool and silk; it leaves them yellow rather than white. For these the fumes of burning sulphur, or these fumes dissolved in water must be

used. No special means of destroying the excess of sulphur fumes is required. These fumes are a compound of sulphur and the oxygen of the air and familiar to every one, in the acid fumes from a burning "sulphur match." The article to be bleached must be *wet,* and then hung in some enclosed space above a piece of burning sulphur. The sulphur candles, to be had at any druggist's, are convenient for this use. Fig. 20. The fumes have great affinity for oxygen, that is, unite with it easily, and take it from the coloring stuffs, converting them into colorless ones. This method of bleaching is sometimes not permanent.

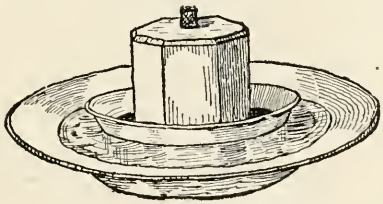

FIG. 20. A SULPHUR CANDLE.

Disinfection

These fumes of sulphur are often used to disinfect rooms where there has been sickness. Its power in this respect is far less than is generally supposed however, and much larger quantities of the gas are required for thorough work than are commonly used. Chlorine gas is an excellent disinfectant, but is dangerous to use because of its irritating effect upon the throat and lungs. The use of "chloride of lime" as a disinfectant depends upon the fact that chlorine slowly

escapes from this substance when it is exposed to the air.

Hydrogen Peroxide

Another bleaching agent of growing importance is peroxide of hydrogen. Water is a compound made up of one-third oxygen and two-thirds hydrogen. Under certain conditions, a compound half oxygen and half hydrogen may be prepared. This is not very permanent as the extra oxygen slowly escapes. This extra oxygen has great power as a decolorizer. The peroxide is a liquid much like water in appearance and is used in bleaching hair, feathers, and ivory. It is the safest bleaching agent for the housekeeper to work with and may be used on wool and silk as well as cotton and linen.

CLEANING WOODWORK

In the interior of the house woods are seldom used in their natural state. The surface is covered with two or more coatings of paint, varnish, etc., which add to the wood durability or beauty. The cleaning processes are applied to the last coat of finish and must not injure this.

Soft woods are finished with paint, stain, oil, shellac, varnish, or with two or more of these combined; hardwoods with any of these, and in addition, wax, or wax with turpentine, or both with oil.

Alkalies on Paint

All these surfaces, except those finished with wax, may be cleaned with a weak solution of soap or ammonia, but the continuous use of any alkali may im-

pair and finally remove the polish. Refinishing will then be necessary. Waxed surfaces are turned dark by water. Finished surfaces should never be scoured nor cleaned with strong alkalies, like sal-soda, or potash soaps. Scouring with these strong alkalies will break the paint or varnish and in this way destroy the finish.

Kerosene in Cleaning

A few drops of kerosene or turpentine on a soft cloth may be used to clean all polished surfaces. The latter cleans them more perfectly and evaporates readily; the former is cheaper, safer, because its vapor is not so inflammable as that of turpentine, and it polishes a little while it cleans; but it evaporates so slowly that the surface must be rubbed dry each time, or the dust will be collected and retained. The harder the rubbing, the higher the polish.

Outside the kitchen, the woodwork of the house seldom needs scrubbing. The greasy layer is readily dissolved by weak alkaline solutions, by kerosene or turpentine, while the imbedded dust is wiped away by the cloth. Polished surfaces keep clean longest. If the finish be removed or broken by deep scratches, the wood itself absorbs the grease and dust, and the stain may have to be scraped out.

CLEANING METALS

Most metals may be washed without harm in a hot alakline solution or wiped with a little kerosene. Stoves and iron sinks may be scoured with the coarser materials like ashes, emery or pumice; but copper, pol-

ished steel, or the soft metals, tin, silver, and aluminum require a fine powder that they may not be scratched or worn away too rapidly. Metal bathtubs may be kept clean and bright with whiting and ammonia, if rinsed with boiling hot water and wiped dry with soft flannel or chamois.

Porcelain or soapstone may be washed like metal or scoured with any fine material.

Tarnish

The special deposits on metals are caused by the oxygen and moisture of the air, by the presence of other gases in the house, or by acids or corroding liquids. Such deposits come under the general head of tarnish.

The metals, or their compounds, in common use are silver, copper and brass, iron and steel, tin, zinc and nickel. Aluminum is rapidly taking a prominent place in the manufacture of household utensils.

There is little trouble with the general greasy film or with the special deposits on articles in daily use, if they are washed in hot water and soap, rinsed well and wiped dry each time. Yet certain articles of food act upon the metal of tableware and cooking utensils, forming true chemical salts.

Silver Sulphide

The salts of silver are usually dark colored and insoluble in water or in any alkaline liquid which will not also dissolve the silver. Whether found in the products of combustion, in food, as eggs, in the paper or cloth used for wrapping, in the rubber band of a fruit jar, or the rubber elastic which may be near the

silver, sulphur forms with silver a grayish black compound—a sulphide of silver. All the silver sulphides are insoluble in water. Rub such tarnished articles, before washing, with common salt. By replacement, silver chloride, a white chemical salt, is formed, which is soluble in ammonia. If the article be not washed in ammonia it will soon turn dark again. With an old or deep stain of silver sulphide friction must be used.

Silver Polish

The analysis of many samples of silver polish, showed them to be made up of either precipitated chalk, diatomaceous earth or fine sand. In using them, it is necessary to be careful in regard to the fineness of material since a few coarse grains will scratch the coating of soft silver. In former times the housewife bought a pound of whiting for fifteen cents, sifted it through fine cloth, or, mixing it with water, floated off the finer portion, and obtained in this way, twelve ounces of the same material for three ounces of which the modern housewife pays twenty-five cents or even more, when she buys it "by the box."

Whiting

The whiting may be made into a paste with ammonia or alcohol, the article coated with this and left till the liquid has evaporated. Then the powder should be rubbed off with soft tissue paper or soft cotton cloth, and polished with chamois.

Protecting Metals

The presence of water always favors chemical change. Therefore iron and steel rapidly oxidize in damp air or in the presence of moisture. All metallic articles may be protected from such action by a thin

oily coating. Iron and steel articles not in use may be covered with a thin layer of vaseline.

Rust can be removed from iron or steel by kerosene if not too deep.

The tarnish on brass or copper will dissolve in ammonia water, but the objects tarnish again more quickly than if polished by friction.

TEST QUESTIONS

The following questions constitute the "written recitation" which the regular members of the A. S. H. E. answer in writing and send in for the correction and comment of the instructor. They are intended to emphasize and fix in the memory the most important points in the lesson.

CHEMISTRY OF THE HOUSEHOLD.

PART II.

Read Carefully. Place your name and address on the first sheet of the test. Use a light grade of paper and write on one side of the sheet only. *Do not copy answers from the lesson paper.* Use your own words, so that your instructor may know that you understand the subject. Read the lesson paper a number of times before attempting to answer the questions.

1. Name all the substances you can think of which are not soluble in water and are soluble in naphtha or benzine.
2. Does sugar neutralize acid chemically? Why?
3. How is soap made? What is the difference between hard and soft soap?
4. What is "hard" water? How does it act with soap? How is it softened?
5. Explain how "bluing" may make white clothes yellow.
6. Why remove stains when fresh? Why before washing?
7. Why is there danger in using naphtha, benzine, and to some extent alcohol near a light?
8. How do cotton and woolen differ in the effect of acids and alkalies upon them?

9. What precautions must be taken in bleaching or removing stains with chloride of lime solution or with Javelle water?
10. Why is it necessary to have clothes dry before starching if much stiffness is desired?
11. If possible, try to remove some stain by a method given in this lesson and tell of the results.
12. Describe a good method of washing woolens.
13. Why does the drying of a little acid or alkali on a fabric have a very disastrous effect?
14. What is your method of washing dishes?
15. What can you say of acids, alkalies, salts?
16. What is "washing soda?" How should it be used? When should it *not* be used?
17. Why does strong soap or washing soda harm varnish or paint?
18. How does the chlorine in "chloride of lime" bleach?
19. What advantages has ammonia for use in the laundry?
20. Do you understand everything given in this lesson paper? Are there any questions you would like to ask?

NOTE.—After completing the test sign your full name.

CHEMISTRY OF THE HOUSEHOLD.

A Day's Chemistry.

PART III.

CHEMISTRY OF BAKING POWDER

We will suppose that after the strenuous course of cooking, washing, and cleaning outlined for the morning, that the housekeeper still has strength to make soda biscuits for tea, and we will study the chemical action involved.

One of the first chemical methods of securing carbon dioxide to use in making bread rise, was by putting hydrochloric acid and cooking soda together in a dough which might be put into the oven before the gas escaped from it.

Cooking Soda

Cooking soda is a salt called bi-carbonate of sodium. It differs from the ordinary mono-carbonate of soda (washing soda) in yielding twice as much carbon dioxide in proportion to the sodium part of the compound. The saleratus of our grandmother's time was bi-carbonate of *potash*, made from wood ashes. The name is still used, but at all stores, cooking soda would be delivered invariably if saleratus were asked for. The true saleratus costs ten times as much as the soda and is no more effective. The carbonic acid is easily set free by chemical compounds of an acid nature, and new chemical compounds result.

Experiment. Put a little cooking soda into any acid—lemon juice, vinegar, almost any fruit juice—and the carbon dioxide will be seen to escape in tiny bubbles. Part of the acid unites with part of the soda, forming a new salt, and the acid taste will be much reduced or lost.

Heating Cooking Soda

Part of the carbon dioxide in sodium bi-carbonate is driven off by simply heating, leaving ordinary sodium mono-carbonate, washing soda. In using this process, cooking soda is mixed with the flour. The high temperature of the oven drives off carbon dioxide, and the bread puffs up. It is light, but yellow in color. The sodium carbonate remains in the bread and its alkaline nature serves to neutralize the acid fluids of the stomach (gastric juice) so that digestion of the bread may be retarded. The sodium carbonate also acts in some way upon the gluten producing an unpleasant odor.

Early Experiments

Among the first methods proposed was one undoubtedly the best theoretically, but very difficult to put in practice. This depended upon the liberation of carbon dioxide from bi-carbonate of sodium by means of muriatic acid—the method already described. The liberation of gas is instantaneous on the contact of the acid with the "soda" and even a skilled hand cannot mix the bread and place it in the oven without the loss of much of the gas. Tartaric acid, the acid phosphates, sour milk (lactic acid), vinegar (acetic acid),

alum, all of which have been used, are open to the same objection.

Cream of Tartar

Cream of tartar is the only acid substance commonly used which does not liberate the gas by simple contact in cold solution. It unites with "soda" only when heated, because it is so slightly soluble in cold water.

Experiment. To illustrate this stir a little soda and "cream of tartar" into some cold water in a cup. In another cup mix the same amounts of each in warm water. Note the difference in the action produced.

To obtain an even distribution of the gas by thorough mixing, cream of tartar would seem to be the best medium by which to add the acid, but because there are other products which remain behind in the bread in using all the so-called baking powders, the healthfulness of these residues must be considered.

Common salt is the safest residue and perhaps that from acid phosphate is next in order.

The tartrate, lactate, and acetate of sodium are not known to be especially hurtful. As the important constituent of Seidlitz powders is Rochelle salt, the same compound as that resulting from the use of cream of tartar and "soda," it is not likely to be very harmful, even in the case of the habitual "soda biscuit" eater, because of the small quantities taken.

Injurious Products

The various products formed by the chemical decomposition of the alum and "soda" are possibly the most injurious, as these are sulphates, and are thought

to be the least readily absorbed salts. The sale of "alum" baking powder is prohibited in many states.

Taking into consideration then the advantage given by the insolubility of cream of tartar in cold water, and the comparatively little danger from its derivative —Rochelle salt—it would seem to be, on the whole, the best substance to add to the soda in order to liberate the gas, but the proportions should be chemically exact, since too much alkali would hinder the process of digestion. Hence baking powders prepared by weight and carefully mixed, are a great improvement over cream of tartar and "soda" measured separately. As commonly used, the proportion of soda should be a little less than half.

LIGHTING.

By the time supper is over or even before, during a large portion of the year daylight has gone. Our grandmothers would have brought out the candles. Perhaps we shall use a candle to light our way while we carry the butter and food into the cool cellar.

The Candle Flame

The candle flame although small in area is typical of all flames. Flame indicates the burning of a gas for solid substances in burning simply glow and do not burn with flame. When wood and soft coal burn, gases are set free by heat and these gases burn over the bed of fuel, giving the flames.

The general form of the candle flame is a cone widest above the base, or about at the top of the wick. If it is examined carefully it will be seen to consist

of three layers. Fig. 21. The interior part is dark, giving out no light. The second is yellow and is the luminous part, and surrounding this and most easily seen at the base, is a very thin blue layer.

Experiment. If a small splint of wood or a match be placed across the lower part of the flame near the wick for a moment, it will be charred where the outer layers of the flame have touched it, but the centre will not be changed. Press a piece of card board quickly down on the flame from above and remove it before it is set on fire, and a ring of scorched paper will show the shape of the hot part of the flame.

Fig. 21. Flame of a Candle.

The candle consists of hydrocarbons (compounds of carbon and hydrogen). When a match is applied to the wick, the hydrocarbons are melted and the liquid rises on the wick by capillary attraction. The heat changes this to gas (or vapor) which is set on fire, since at the high temperature it easily unites with the oxygen of the air. There is plenty of oxygen present, but it is all seized upon by the carbon and hydrogen in the outer parts of the column of gas rising from the wick, so that none reaches the centre. The gas diffuses outward toward the oxygen continually, so that the inner cone may be regarded as a gas factory. The yel-

Chemistry of the Candle Flame

low light is caused by the incandescence or glowing of small particles of carbon, heated to "white heat." These are set free from the compounds where the flame is very hot and they are not yet united with oxygen.

Nature of Smoke

Flames "smoke," that is, throw off unburned carbon when there is an insufficient supply of oxygen. Any device which constantly renews a steady supply of air (with oxygen) will make the flame burn better. The chimney of a lamp does this by protecting the flame from wind and by making, enclosing, and directing upward a current of air. The chimney makes the lamp "draw," as the chimney of the house makes the stove "draw."

Explosions

When the air is mixed with an inflammable gas and the temperature of any part is raised to the kindling point of the gas, as happens if a light is brought into such a mixture, an explosion takes place. The flame spreads through the whole and combination ensues everywhere almost instantly. Great heat is produced and the gases expand suddenly and with violence. If the gases are confined, the enclosing walls may be broken by the pressure. Contraction follows this expansion and air rushes in, producing a second sound. The sounds occur so near together as to give the impression of one.

Explosive Mixtures

In a mixture of inflammable gas and air there must be a certain proportion of each to give conditions which will produce an explosion. A very small amount of gas in the air will not explode under any conditions,

as when there is an odor of coal gas in the room from which no explosion follows even though a light be present. On the other hand, a mixture containing a large proportion of inflammable gas and a little air will not explode. The proportion of air to gas in an explosive mixture varies in different cases, but in general ranges from about twelve to five parts of air to one

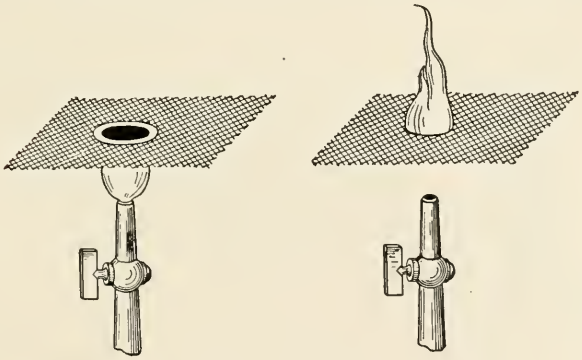

Fig. 22a. The Effect of Wire Gauze on a Gas Flame.

part of gas. It is, of course, never safe to rely on the chance of the correct proportions of gas and air not being present.

Explosions sometimes occur by unwise use of kerosene in kindling a fire in a stove. If the kerosene is poured upon a fire already burning, enough vapor of kerosene may be produced to give a disastrous explosion. Soaking wood or paper in kerosene for use as kindlings and then lighting would produce no such dire results.

Safety Lamps

Explosions in mines are usually caused by a gas called fire-damp and composed of carbon and hydrogen. When this escapes from the coal and becomes mixed with air, it is very explosive. If a miner brings a naked flame into the mine, the fire-damp will ignite and disaster results. A safety lamp was devised by Davy for use in such dangerous places. It was found that a gas is cooled below its kindling temperature in passing through a fine wire gauze. Lamps surrounded by such a gauze may be taken into a mine with comparative safety. Fig. 22.

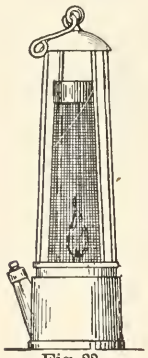

Fig. 22

The action of the wire gauze upon the gas may be studied by holding over a gas jet a piece of fine wire netting, such as is used in window screens, and then lighting the gas above the netting. Fig. 22a. It will be seen that the gas below the netting is very slow in igniting, since it does not readily become sufficiently heated, the wire netting cooling it below its kindling point.

Kerosene Lamps

The kerosene lamp gives light by the principle already described. The reservoir of the lamp corresponds to the cup of melted tallow at the top of the candle. The oil is drawn to the top of the wick by capillary attraction, where the heat vaporizes it; so that vapor and not oil is what really burns. The structure of the flame is precisely like that of the candle, although its shape differs, because of the shape of the wick.

Coal Gas

Illuminating gas is today the source of light in most city houses. There are two kinds of gas now furnished for this purpose. Coal gas is obtained from the destructive distillation of soft coal. Receivers or retorts of iron or fire clay are filled with soft coal and heated to 1100° or more. From these retorts tubes lead up into a large pipe called the hydraulic main,

Distillation of Coal

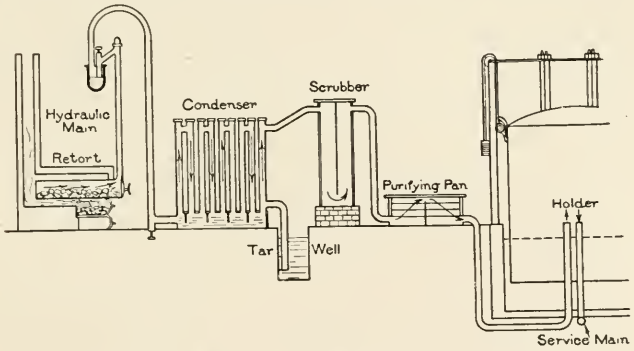

FIG. 23. MANUFACTURING OF COAL GAS.

through which water is kept flowing. As the coal becomes heated, a number of different substances are given off, which at this high temperature are in the gaseous state. Some of them dissolve in the water of the hydraulic main, but those needed for illuminating gas are not soluble and passing out of the main, they travel through several hundred feet of vertical pipe called the condenser, where more water removes any impurities which may have escaped from the hydraulic main.

Purifying Coal Gas

The gases are then passed on through numerous other devices to remove remaining traces of impurities, and are finally collected in a circular chamber known as the gas-holder, from which they are distributed to the consumer. Fig. 23.

If the purification is not perfect, the coal gas will contain sulphur compounds, and these on burning produce oxide of sulphur, which is further changed by moisture and the air into sulphuric acid. The quantity produced may be very minute and yet in time may be sufficient to damage books and fabrics.

Aniline

The materials which collect in the hydraulic main and the condensers contain many useful substances, one of the most valuable being ammonia. Among the most interesting substances obtained from coal tar is aniline from which beautiful dyes are made. Aniline itself is a colorless liquid, but in combination with other chemical substances it yields a wide range of beautiful colors now used in dyeing. Other useful substances obtained from the distillation of coal tar are carbolic acid, a disinfectant, and naphthalene which is sold in the form of moth balls.

Water Gas

In some cities what is known as water gas forms the basis of the illuminating gas. This is made by passing very hot steam over red hot anthracite coal or coke. The oxygen of the water unites with the carbon of the coal, forming carbon monoxide—a compound of one part oxygen and one part carbon—and the hydrogen of the water is set free. Both the gases

thus formed will burn, but in burning they produce a colorless flame. It is therefore necessary to mix with them some gases containing much more carbon which will give light when burning. The mixture is stored and distributed like coal gas.

This gas is cheaper to manufacture in most localities, but it contains much more carbon monoxide which is a very poisonous gas. Much discussion has arisen as to the safety of using water gas and in some places its manufacture is forbidden by law.

Natural Gas

The destructive distillation of vegetable and animal life in the depths of the earth, caused by the great heat within the earth, has in some places given rise to petroleum and natural gas. The gas gave a cheap and convenient fuel, but unfortunately the supply is becoming rapidly exhausted.

Acetylene

An illuminating gas of growing importance today is acetylene. This is a compound of carbon and hydrogen and is prepared by the action of water upon calcium carbide, which is a compound of carbon and the element calcium. Calcium carbide is manufactured in large quantities at Niagara Falls where pure lime mixed with powdered charcoal is fused at an intense heat. A dark gray crystalline solid results which, when mixed with water, produces acetylene gas and slaked lime.

Acetylene is a colorless gas of characteristic odor, soluble in water, and explosive if mixed with air. With an ordinary burner it makes a yellowish smoky

flame, but with a properly constructed burner, it gives a brilliantly white light, very like sunlight. Colors appear at their true values seen in this light. The flame is an intensely hot one. In acetylene burners the gas escapes through two very minute holes directed obliquely towards each other, as shown in Fig. 24.

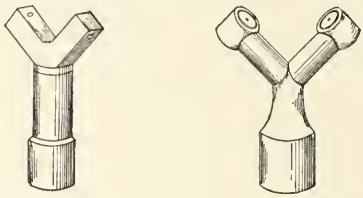

FIG. 24. ACETYLENE GAS BURNERS.

Acetylene Generators

The gas has been somewhat in disrepute because of lack of a suitable arrangement for making and storing it. Many generators are upon the market, it is true, but very few of these are really safe. As soon as a reliable one is obtainable, the gas will be widely used for lighting. It may also be used for cooking, but at present is rather expensive. One form of generator is illustrated in Fig. 25. The calcium carbide in lumps is fed automatically into water as long as the gas is used. When the storage tank is nearly full the supply of carbide is automatically shut off. In another style, which is also automatic, water is fed on to the lumps of carbide. Both styles have their advocates, but the lump feed generator is most generally recommended. The apparatus costs from about $65.00 for a 10 light plant to $300.00 for a 100 light plant.

Gasoline Gas

A cheaper gas than acetylene is gasoline gas, sometimes called carburetted air gas because it is common air impregnated with the vapors of gasoline. It burns with a rich, bright flame similar to coal gas and

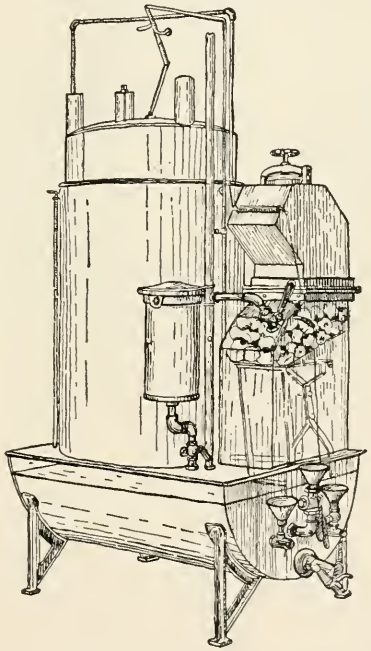

Fig. 25. Acetylene Gas Generator and Storage Tank.

is conducted through pipes and fixtures in the same manner. It may be used in an ordinary gas stove.

The gas machine consists of a generator containing evaporating pans, an automatic air pump operated by

a heavy weight or by a water motor, together with a regulator or mixer. The general arrangement is shown in Fig. 26, the generator being entirely outside the building in which the gas is used. All such machines require intelligent care, for several disastrous

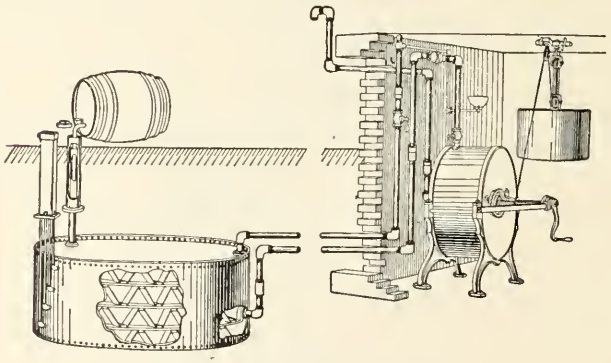

FIG. 26. GASOLINE GAS PLANT.

explosions have taken place when such care has not been given to the apparatus.

LIME.

One of the common chemical substances found about the country house at least is quick lime, used for whitewash and as a deodorizer.

Oxide of Calcium

The term lime usually means the oxide of the element calcium. Its commonest compound is calcium carbonate which is found in nature as limestone, chalk, marble, coral, shells, and several other familiar substances. Calcium is also found combined with sulphur and

oxygen in the compound calcium sulphate, which is the mineral gypsum from which plaster of Paris is made. Bones contain a considerable amount of calcium phosphate and egg shells, calcium carbonate.

Quick Lime

Lime, the oxide of calcium, is made by heating broken pieces of limestone in furnaces called lime kilns. The calcium carbonate as a compound is broken up, carbon dioxide gas being given off and calcium oxide left. This freshly formed oxide is called "quick lime," and when it is exposed to moist air, it attracts water and changes to a form called chemically, calcium hydroxide and, commonly, "slaked lime." Quick lime may be used to dry the air of damp cellars, etc., because of this property. The process of slaking the lime is also accomplished by treating quick lime with water. When this is done, much heat is evolved and the hard lumps crumble to a soft powder and increase considerably in bulk. The rise in temperature shows that chemical change is taking place.

Lime Water

Slaked lime will dissolve slightly in water, yielding lime-water. This is a mild alkali and has several household uses. It may be prepared by pouring two quarts of boiling water over about a cubic inch of unslaked lime. Stir it thoroughly and let it stand over night; in the morning pour off the liquid and treat the sediment with hot water a second time. When the sediment has again settled, pour off the clear liquid and bottle this. It is mixed with milk and fed to young children and invalids to prevent acidity of the

stomach and make the milk more easily digested. Lime-water and oil form one of the best remedies for burns. The alkali of the lime neutralizes the acid nature of the burn.

Mortar and Plaster

Mortar is made of slaked lime and sand. When this is spread upon the walls, the lime slowly absorbs carbon dioxide, always present in the air, and changes to carbonate of lime. The water is given off into the air (evaporates) and the mass becomes hard. Of course the surface becomes carbonate sooner than the deeper parts because this has closer contact with the air, and it therefore takes considerable time for all the plaster to harden. The water contained in the mortar soon dries, but while the mortar is becoming hard, more water is continually formed in the chemical process, so that it requires a long time for the new plaster to become quite dry. It is considered unhealthy to live in rooms with newly plastered walls. This may be because such walls are damp, thus producing damp air, or it may be because the moisture in the walls interferes with the passage of air and other gases through the walls—a process little considered as a rule, but of great importance.

Hydraulic Cement

Certain varieties of limestone contain other salts, such as magnesium carbonate. Lime made from these does not soften from exposure to the air. It will, however, harden after long contact with water, and such substances are known as *cements*. Portland cement will harden under water.

Quick-lime is a strong alkali and does the work of such substances. It is used in tanneries in taking hair from hides and also in decomposing fats for making candles. When dead animal substance is buried in lime, the process of decomposition is greatly hastened, probably because the lime unites with all water present while the strong alkali acts upon the fats reducing them to soaps of different kinds.

Whitewash

Whitewash is simple slaked lime mixed with water. It is very cleansing in its effects and also gives the appearance of freshness and cleanness. When newly applied, it is nearly colorless, for the calcium hydrate is colorless; this in the air soon changes to calcium carbonate which is white and opaque.

CHEMISTRY AND ELECTRICITY.

In most houses electricity is used for operating the door bell, table bell and perhaps the electric gas lighters. We have learned how stored up chemical energy is changed into heat and force in the stove and in the human body; but in the electric cell, chemical energy is changed into electrical energy.

A Voltaic Cell

If a strip of pure zinc be placed in a weak solution of acid, no chemical action takes place. Place in the same solution a strip of sheet copper and again no action takes place; but let the copper and the zinc be brought in contact, or connected by a copper wire, and immediately vigorous chemical action will begin at the surface of the copper plate; bubbles of hydrogen collecting there. This action is as follows: the zinc dis-

solves in the acid and hydrogen is set free. This hydrogen travels with an electric current set up in the liquid, passing from particle to particle through the liquid until it reaches the copper. Here the hydrogen stops, but the electric current passes up the copper plate and over the wire to the zinc and down that to

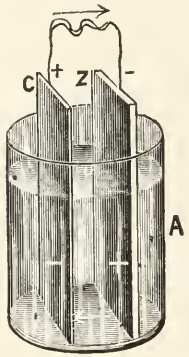

Fig. 27. A Simple Voltaic Cell.

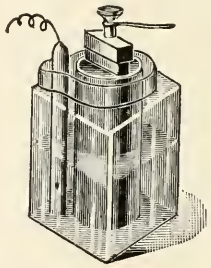

Fig. 28. A Leclanche Cell.

the liquid and so on. This arrangement of acid and metals is called a *simple voltaic cell.* Fig. 27.

Leclanche Cell

Other cells are arranged with different liquids and solids to gain various ends, and several cells may be united by wires between the plates to gain additional strength of current. The form of cell often employed to work electric bells is the Leclanche cell. Fig. 28. This consists of a plate of carbon (or a porous cell containing carbon), in place of the copper, a strip or rod of zinc, and a solution of ammonium chloride

which takes the place of the acid. The zinc is not affected by the ammonium chloride unless it is connected with the carbon, but when there is a circuit for the electricity, a current is generated. The common conductors of the electric current are the metals and carbons.

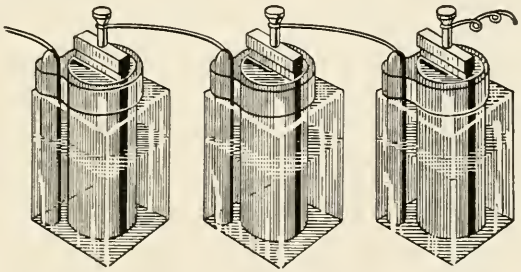

Fig. 29. A Battery of Cells Connected in Series.

Renewing Batteries

The zinc is gradually changed to zinc chloride, at the expense of the ammonium chloride, and after a time both the zinc and the ammonium chloride must be renewed. In renewing the battery, the jars should be cleaned out carefully and the zincs renewed if they are completely eaten through. A quarter of a pound of pure ammonium chloride (sal-ammoniac) is dissolved in enough water to about half fill a jar. When the carbon and the zinc are replaced, this will bring the liquid up to two inches from the top. The jar should not be filled too full. The wires which have been disconnected should be reconnected as before.

Cells in Series

For bell work the cells are usually connected up "in series," that is, the zinc of one cell is connected to

the carbon of the next, the outside circuit being established between the end carbon and end zinc. Fig. 29.

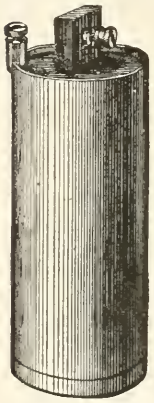

Fig. 30. A Dry Cell.

If there is a short circuit anywhere in the line, that is, if the current has a chance in any way to flow from one wire to the other without going through the bell or other apparatus, the batteries are very quickly exhausted.

A modification of this cell has been made in which the spaces inside it are filled with some spongy mass in the pores of which the ammonium chloride is held. These may easily be carried about without danger of spilling solutions. They are called *dry cells* and when exhausted cannot readily be renewed.

PLANTS.

Most housekeepers have at least a few house plants and many have gardens which occupy part of the time each day. All foods are directly or indirectly produced by plants and it is well to consider also what food these living things require in their turn.

Plant Foods

Plants are able to take from the materials forming the crust of the earth and from the air surrounding them all that they need for their life. The leaves of the plants, because of the green substance called

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chlorophyl, have the power of decomposing carbon dioxide gas in a such a way that plants make use of the carbon and breathe out oxygen. Fig. 31. This separation is very difficult to make in the laboratory. The energy of sunlight is utilized by the plant for this work, for the action does not take place in darkness. In this way plants return to the air the oxygen so necessary for animal life and are themselves fed in part by the useless and even harmful gas exhaled by animals.

Chlorophyl

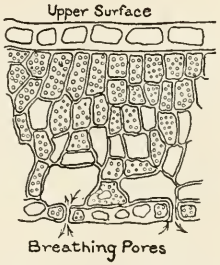

Fig. 31. Section Through a Leaf.

The soil on which the plant grows furnishes the mineral matter needed. When plant tissues are burned, these mineral substances remain as ashes. When the ashes of plants are analyzed, they are found to consist of potash, soda, iron, and lime in the form of phosphates, sulphates, and silicates. Some of these substances are present in the soil in inexhaustible quantities, but others are less abundant and unless the soil be fertilized from time to time, the plant soon uses them up. These less abundant substances are phosphates, potash, and nitrogen.

Fertilizers

The lover of house plants has long resorted to various expedients for feeding them, and many plant foods are now sold and in common use. In using these for manuring potted plants, care must be taken not to

use too much, since strong solutions of them are likely to corrode the roots and kill the plants.

Nitrogen and Plant Life

Although nitrogen is a very abundant element, forming as has been said, four-fifths of the air, yet it is comparatively rare in forms which are of use to plants. As a rule plants cannot take it from the air and therefore require soluble compounds of nitrogen for food. One of the most important of these is ammonia. This is formed when organic substances decay, its odor being very noticeable about stables. Its action with acids was described in the pages about cleaning and it was explained how it unites with acids to form salts, usually soluble. Sulphate of ammonia is the form used in agriculture. A *very little* ammonia in the water used on house plants is a good thing for them.

It has been seen that plants by aid of sunlight breathe in carbon dioxide and breathe out oxygen gas. In addition to this, they also breathe as animals do, to a slight extent, taking in oxygen and breathing out carbon dioxide. This action is more pronounced in darkness.

Conservation

The wonderful principle called conservation is illustrated by what we know of plant life. Plants in growing store up energy derived from the heat and light of the sun. When they decay, or are burned, or are eaten by animals, exactly the same amount of energy is set free and changed into a new form, and just as much carbon dioxide as the plant breathed in, is given back to the air. A plant which was many

years in growing may be consumed in an hour or may decay slowly for years. In either case the same total amount of energy is set free, fast or slowly. This energy is most apparent as heat. In the growth and destruction of the plant both energy and matter have been transformed, but neither energy nor matter has been made or lost—it has merely taken on a new appearance. When animals feed on plants they transform the energy of sunlight which is stored up in the plant into energy of vitality. In this sense man and all animals are "children of the sun."

CHEMICAL TERMS.

To explain various chemical and physical phenomena the scientists consider that matter consists of certain small molecules and atoms.

If a drop of water be divided and sub-divided indefinitely, it is conceivable that a point would come when it could not be divided further by physical means. This final bit of water is called a molecule. It would be far from visible by the most powerful microscope. From calculation which we will not go into, we learn that a few hundred million ordinary sized molecules would cover the space of a pin head.

Molecules

If the water is broken up by some powerful force as by the electric current, we have seen that two different substances are obtained—oxygen and hydrogen. Consequently the molecules of water must have been made up of other still smaller particles and these are called atoms. The atoms of a chemical element, then,

are of the same kind, for from an elemental substance like oxygen, only oxygen can be obtained by any means now known.

Atoms

The atoms may be likened to the letters of our alphabet and the molecules to the words. From a few different kinds of atoms (letters) can be made a great variety of molecules (words).

TABLE OF COMMON ELEMENTS.

Aluminum	Al	Iodine	I	Oxygen	O
Arsenic	As	Iron	Fe	Phosphorus	P
Barium	Ba	(Ferrum)		Silicon	Si
Boron	B	Lead	Pb	Silver	Ag
Calcium	Ca	(Plumbum)		(Argentum)	
Carbon	C	Magnesium	Mg	Sodium	Na
Chlorine	Cl	Manganese	Mn	(Natrium)	
Copper	Cu	Mercury	Hg	Sulphur	S
Gold	Au	(Hydrargyrum)		Tin	Sn
(Aurum)		Nickel	Ni	(Stannum)	
Hydrogen	H	Nitrogen	N	Zinc	Zn

The atoms of an element are all exactly alike. They weigh the same and act the same whatever their source. Two or more atoms of an element may combine to make a molecule of that element. The molecules of a chemical substance are always composed of the same number and kind of atoms.

Chemical Signs

To express the composition of substances chemists have made use of certain abbreviations and signs. To indicate an atom of hydrogen the letter H is used and for oxygen, the letter O, for nitrogen, N, and so on as shown in the table.

When expressing a compound the number of atoms is indicated by sub-script; for example, H_2 means two

atoms of hydrogen; H_2O expresses two atoms of hydrogen and one atom of oxygen, and as we have found, this is the composition of water; so H_2O is the chemist's short way of indicating water. These are called chemical formulas. The formula for sulphuric acid is H_2SO_4. This indicates that it is made up of two atoms of hydrogen, one atom of sulphur, and four atoms of oxygen. The following table gives the chemical formulas of many of the chemical substances found in the household.

Expressing Molecules

THE HOUSEKEEPER'S LABORATORY.

All modern science is based upon experiment. Chemistry was hardly a science until experimental research began. It must be confessed that the average housewife seldom thinks of making experiments. She is apt to remain helpless before any new problem of the home without printed directions or advice from friends. Very often the easiest and surest way to find out a thing is to *try it*. Use your kitchen as a laboratory. It would, of course, be most unwise to make experiments on expensive materials. For example, if a stain was to be removed from colored goods, it would be best to find the effect of the chemicals to be used on some small piece of the fabric.

Experiments

To test the color of a sample of gingham for fastness in washing, try a part of the sample in soap and hot water and see if the color "runs" or stains the water. Dry and iron the piece treated and compare with the portion of the original sample kept. A sample can be

Testing Colors

TABLE OF COMMON SUBSTANCES AND THEIR FORMULAS.

SUBSTANCE	FORMULA	SUBSTANCE	FORMULA
Water	H_2O	Calcium Oxide (Lime)	CaO
Peroxide of Hydrogen	H_2O_2	Lime Water	$CaOH$
Sulphuric Acid	H_2SO_4	Calcium Carbonate	$CaCO_3$
Sulphur Dioxide	SO_2	Calcium Hypochlorite (Chloride of Lime)	$Ca(ClO)_2$
Hydrochloric Acid	HCl	Sodium Thiosulphite ("Hypo")	$Na_2S_2O_3$
Acetic Acid	$C_2H_4O_2$	Cane Sugar	$C_{12}H_{22}O_{11}$
Tartaric Acid	$C_4H_6O_6$	Milk Sugar	$C_{12}H_{22}O_{11}+H_2O$
Cream of Tartar (Acid potassium tartrate)	$KC_4H_5O_6$	Grape Sugar	$C_6H_{12}O_6$
Carbon Dioxide	CO_2	Starch	$(C_6H_{10}O_5)x$
Carbon Monoxide	CO	Cellulose	$(C_6H_{10}O_5)y$
Caustic Soda	$NaOH$	Stearine (in fat)	$C_3H_5(O_2C_{18}H_{35})_3$
Caustic Potash	KOH	Palmitin (in fat)	$C_3H_5(O_2C_{16}H_{31})_3$
Sodium Carbonate (*Anhydrous*)	Na_2CO_3	Soap	$NaO_2C_{18}H_{35}$, $NaO_2C_{16}H_{31}$, etc.
Sodium Carbonate (*Crystalline*) (Washing Soda)	$Na_2CO_3+12H_2O$	Albumen	(*Not definitely known.*)
Sodium Bicarbonate	$NaHCO_3$	Alcohol	C_2H_5OH
Ammonia (*gas*)	NH_3	Wood Alcohol	CH_3OH
Ammonium Hydrate (Ammonia Water)	NH_4OH	Glycerine	$C_3H_5(OH)_3$
		G'soline, N'phtha	C_6H_{14}, C_7H_{18}.
		Benzine, etc.	C_6H_{18}, etc.

tested for fastness to light by exposing to direct sunlight for a day or two, saving a portion of the cloth as before for comparison. If the dye will stand direct sunlight without appreciable change for this length of time, it will not give much trouble by fading. Wall paper may be tested for fading in a similar way.

Testing by Comparison

The industrial chemist always endeavors to test materials in a manner as nearly like the way they are to be used as possible. For example, if he were testing two samples of flour to be used for making bread, he might make up two small loaves, using carefully weighed quantities of each sample of flour and other materials and baking the loaves at one time, compare the result. In such cases it is usual to have a "standard" flour or other material to use for comparison.

This method of testing by comparison could often be used by housekeepers provided reasonable care were taken as to weights and conditions. Working thus, flour, baking powder, soap, spices, flavoring extracts, in fact almost all the raw materials of the kitchen and laundry could be tested.

Household Chemicals

The chemicals for household use are chiefly acids, alkalies, and solvents for grease. Acids and alkalies are opposed to each other in their properties and if too much of either has been used, it may be rendered innocent or neutralized by the other; as when soda has turned black silk brown, acetic acid or vinegar will bring the color back.

Acids for the Laboratory

The acids which should be on the chemical shelf for the household are acetic, hydrochloric (muriatic), oxalic. Vinegar may be used in many cases instead of acetic acid, but vinegar contains coloring matter which stains delicate fabrics and it is better to use the purified acid. Hydrochloric and oxalic acids are strong acids and will harm most household materials if allowed to act for *long time*. Acetic acid is a weak acid and as it is volatile, evaporates without becoming concentrated as do the others.

Some bright blue flannels and other fabrics, when washed with soap or ammonia become changed or faded in color. If acetic acid or vinegar be added to the last rinsing water, the original appearance may be restored. Not all shades of blue are made by the same compounds, hence not all faded blues can be thus restored.

Care of Chemicals

The use of these acids has been indicated in the previous pages, and there remains to be considered, only certain cautions. *Hydrochloric acid* is somewhat volatile. It will escape even around a glass stopper and will eat a cork stopper; therefore, either the glass stopper should be tied in with an impervious cover—rubber or parchment—or a rubber stopper used, for the escaping fumes will rust metals and eat fabrics.

Oxalic acid should be labeled POISON.

The bleaching agents, *"chloride of lime"* and *Javelle water* owe their beneficent effect to substances of an acid nature which are liberated from them. They

should all be used in solution only, and should be kept in bottles with rubber stoppers.

Sulphurous acid gas, obtained by burning sulphur, will often remove spots which nothing else will touch. The amount given off from a burning sulphur match will often be sufficient to remove from the finger fruit stains or those made by black kid gloves.

The alkalies which are indispensable are: Alkalies

1st. *Ammonia*—better that of the druggist than the often impure and always weak "household ammonia." The strong ammonia is best diluted about one-half, since it is very volatile, and much escapes into the air.

2nd. *Potash* and *Caustic Soda,* which are to be had at the grocers in small cans. The lye obtained from wood ashes owes its caustic and soap-making properties to potash. The caustics are corrosive in their action, and must be used with discretion.

Crystallized sodium carbonate, the sal-soda of the grocer, is chemically speaking a salt and not an alkali, but it gives all the effect of one, since the carbonic acid is so weak that it readily gives place to other substances.

Sal-soda is a very cheap chemical, since it is readily manufactured in large quantities, and forms the basis of most of the washing powders on the market. With grease, it forms a soap which is dissolved and carried away.

3rd. *Borax* is a compound of sodium with boric acid, and acts as a mild alkali. It is the safest of all the

alkalies, and affects colored fabrics less than does ammonia.

Solvents

Solvents for grease are alcohol, chloroform, ether, benzine, naphtha, gasolene—all volatile—kerosene and turpentine. Of these chloroform is the most costly, and is used chiefly for taking spots from delicate silks. Fabrics and colors not injured by water may be treated by alcohol or ether. Benzine, naphtha or gasolene are often sold, each under the name of the other. If care is taken to prevent the spreading of the ring, they can be safely used on any fabric. They do not mix with water, and are very inflammable.

The less volatile solvents are kerosene and turpentine. Kerosene is a valuable agent in the household, and since some of the dealers have provided a deodorized quality, it should find an even wider use. The lighter variety is better than the 150-degree fire test, which is the safe oil for lamps. As has been indicated in the preceding pages, the housewife will find many uses for this common substance.

On account of the purity and cheapness of kerosene, turpentine is less used than formerly, although it has its advantages.

Closet for Chemicals

These household chemicals should have their own closet or chest, as separate from other bottles as is the medicine chest, and especially should they be separated from *it*. Many distressing accidents have occurred from swallowing ammonia by mistake.

In addition to these substances, certain others may be kept on hand, if the housewife has sufficient chemical

knowledge to enable her to detect adulteration in the groceries and other materials which she buys.

A few of these simple tests are given with the chemicals needed. Tests

Directions for Using the Housekeeper's Laboratory.

When directed to make a solution acid or alkaline, always test it by means of the litmus paper:

Blue turned to red means acid. Red turned to blue means alkaline.

Only by following the directions can the test be relied upon. Under other circumstances than those given, the results may mean something else.

Use the acids in glass or china vessels only. Metals may be attacked. Do not touch brass with ammonia or marble with acid. Aluminum is quickly corroded by the alkalies. Vessels

Heating or burning a substance often gives evidence of its character. Organic solids will char, leaving charcoal (carbon) when heated and will disappear completely when burned. Some salts melt; others do not.

All the carbonates that the housewife is likely to meet will give an effervescence of carbon dioxide with muriatic acid and most of them with acetic acid. Carbonates

Substances of an acid nature will effervesce with a solution of cooking soda. The test will be more delicate if the solutions are warm.

To test for *sulphuric acid* or soluble *sulphate* in soda, cream of tartar, baking powder, vinegar, sugar or

syrup: Add muriatic acid to the solution (if the insoluble part is sulphate of lime, it will dissolve in the acid on heating), then add barium chloride. A heavy white precipitate proves the presence of sulphuric acid, either free or combined. If the solution is not distinctly acid at first, it is not free.

Lime Test

To test for *lime* in cream of tartar, baking powder, sugar or syrup: Make the solution alkaline with ammonia and ammonium oxalate. A fine white precipitate proves the presence of lime. Good cream of tartar will dissolve in boiling water, and will show only slight cloudiness when the test for lime is applied.

Phosphates

To test for *phosphates* in cream of tartar or baking powder: Make acid by nitric acid, and add ammonium molybdate. A fine yellow precipitate or yellow color proves the presence of phosphates.

Chlorides

To test for *chlorides* in soda, baking powder, sugar, syrup or water: Make the solution (a fresh portion) acid with nitric acid, and add silver nitrate. A white curdy precipitate or a cloudiness indicates chlorides.

Ammonia

To test for *ammonia* in baking powder: Add a small lump of caustic soda to a strong water solution. Red litmus will turn blue in the steam, on heating.

Alum

To test for *alum* in cream of tartar, baking powder or bread: Prepare a fresh decoction of logwood; add a few drops of this to the solution or substance, and render acid by means of acetic acid. A yellow color in the acid solution proves absence of alum. A bluish

or purplish red, more or less decided, means more or less alum.

Starch

To test for *starch* in any mixture which has been cooked, simply moisten with dilute tincture of iodine such as is kept by the druggists. An intense blue color will show the presence of even a minute quantity of starch. If the substance has not been heated, boil a portion and *let cool* and then test with a few drops of iodine solution. Heat destroys the blue color of iodine with starch and therefore the test must be made in cold solutions.

Washing Powder

If the label of a washing powder claims it to be something new, and requires that it be used without soda, as soda injures clothes, it can be tested as follows: Put half a teaspoonful of the powder into a tumbler, add a little water, then a few drops of muriatic acid. A brisk effervescence will prove it to be a carbonate, and if the edge of the tumbler is held near the colorless flame of an alcohol lamp, the characteristic yellow color of sodium will appear and complete the proof. If the acid is added drop by drop, until no more effervescence occurs, and there remains a greasy scum on the surface of the liquid in the tumbler, the compound contains soap as well as sal-soda, for the acid unites with the alkali of the soap and sets free the grease. Acetic acid or a solution of oxalic acid may be used in place of the muriatic acid.

Silver Polish

If some very costly silver polishing powder is offered as superior to all other powders, a drop or two of

muriatic acid or of warm vinegar will decide whether or not it is chalk or whiting by the effervescence or liberation of the carbonic acid gas.

Sample Tests

In making all the foregoing tests, it is well to observe the effect of the chemicals used on the substance to be tested for, and so become familiar with the characteristic color or appearance of the test. For example, before testing a washing powder, add a little acid to a soap solution and observe the greasy film produced, and in testing for alum add a very little alum solution to some flour and test with the logwood solution, noting the color given. This procedure will lead to more reliable results.

Caution! Use a new solution of a fresh portion of the first one for each new test and follow directions exactly. This is essential to remember.

TEST QUESTIONS

The following questions constitute the "written recitation" which the regular members of the A. S. H. E. answer in writing and send in for the correction and comment of the instructor. They are intended to emphasize and fix in the memory the most important points in the lesson.

CHEMISTRY OF THE HOUSEHOLD.

PART III.

Read Carefully. Place your name and address on the first sheet of the test. Use a light grade of paper and write on one side of the sheet only. *Do not copy answers from the lesson paper.* Use your own words, so that your instructor may know that you understand the subject. Read the lesson paper a number of times before attempting to answer the questions.

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1. What properties of "cream of tartar" make i suitable for baking powder?
2. Explain how a candle is a gas factory.
3. What conditions must be present for an explosion to take place?
4. What is "cooking soda?" How does it differ from washing soda?
5. What is the principle of the Davy safety lamp?
6. Describe the manufacture of coal gas.
7. How is water gas made? What objectionable features has it?
8. What is "quick lime" and what are its uses?
9. How is electricity produced in a voltaic cell?
10. What does the chemical formula H_2SO_4 indicate?

11. How is "conservation" illustrated in the life and decay of a tree?

12. What can you say about the advisability of the housekeeper making experiments?

13. How would you test for a carbonate? How for an acid without using litmus paper?

14. How are tests made by comparison?

15. Are there any questions you would like to ask relating to "A Day's Chemistry"?

16. Have you any personal experience, original method, or new fact to offer, relating to the subjects taken up in the lesson on the "Chemistry of the Household" that would be of interest to your fellow students?

Note.— After completing the test, sign your full name.

SUPPLEMENT

CHEMISTRY OF THE HOUSEHOLD

By Margaret E. Dodd, S. B.

In reading many hundreds of test papers written by our students I have found that additional comments suggest themselves frequently, and it may be of interest to bring them together here.

IMPURITIES IN WATER

By the term impurities, we mean substances out of place. Pure water is oxide of hydrogen, H_2O. If water has salt dissolved in it, for instance, the salt is an impurity for the water, though we do not think of salt as being an impure substance in itself. The mineral impurities in drinking water are seldom a source of danger, although if the amount is large, such water may not "agree" with persons not used to it. Mineral impurities will usually make the water hard, and therefore troublesome for laundry work and to some extent in cooking.

LAUNDRY WORK

Satisfactory water for laundry work must not only be clear and soft but it must be free from iron, from the discoloration due to decaying vegetable matter, clayey soil, and so on. It should also be free from any odor when hot. Muddy water may be cleared more

or less satisfactorily by filtering it through sand or "by precipitation." In the latter method, dissolve a scant tablespoonful each of alum and borax in a little hot water, and add this amount to each gallon of water used, stirring it in, and allowing it to settle. The alum and borax react to form a cloudy substance which settles to the bottom, carrying the mud with it. The clear water must then be carefully poured or dipped off from the sediment. A siphon is an excellent contrivance for such a use. If a piece of garden hose is used, tie on a piece of wood so that it extends one or two inches beyond the end, to keep it above the sediment. Weight it with a piece of lead.

When water made hard by carbonate of lime is to be softened, addition of any of the alkalis will soften it, for this reason. These carbonates will not dissolve in water unless it contains carbon dioxide gas in solution. The alkalis added, unite with the gas, and the lime is thereby made insoluble and separated from the water. We do not see it as a rule, for there is in reality, very little of it, and this little separates in very tiny particles. Water which is hard in the clothes boiler frequently causes trouble because of tiny bits of lime which separate from it and make spots upon the clothes.

A spring situated in sandstone rock generally yields soft water because the sandstone is so slightly soluble, but one situated in limestone rock always gives hard water. Limestone is a very common rock,

so many springs are of hard water. A shallow well is more apt to yield soft water than a deep one is, and a river has clearer and softer water near its source, where it runs over rocks, and through uncultivated land.

Occasionally where free alkali is added to hard water, it unites with greasy or oily matter in the garments being washed, and forms dark spots of soap insoluble in water. This is prevented to some extent by addition of a very little turpentine, and boiling such spotted garments in clean suds may dissolve out the stains if they have formed. This happens so seldom that the use of soda in laundry work (with caution) for softening water is still to be recommended

Washing powders are usually composed for the most part of washing soda, and as they cost more than soda, it is rather better to buy the latter. Moreover, the strength of the alkali may be more accurately judged.

Water varies greatly in hardness, so it is difficult to give exact rules for softening it, though I am often asked for them. In general, for moderately hard water use:

1 level tablespoonful of sal soda to 1 gallon water.

½ level tablespoonful of powdered lye to 1 gallon water.

1 level tablespoonful of borax to 1 gallon water.

Do not use ammonia with very hot water, for heat liberates the ammonia gas, which is thus lost.

Some students have thus described the use of ashes from hard wood:

Add a quart or more of water to a quart of ashes. Boil it a few minutes, adding more water if necessary. Then add sufficient water to make a gallon. Let it settle, then pour off the water and strain it. Put enough of it in the wash water to secure a good suds with soap. The water dissolves the potash (potassium carbonate) from the ashes. So this is an economical method of getting this alkali.

I have had many interesting letters on the subject of laundry work. Some of the processes described may be new to many of our students.

One writer describes a method of using paraffine in washing. She dissolves a bar of soap in boiling water and adds to it a piece of paraffine almost as large as a walnut. She uses this in making a suds with *boiling* water in which the clothes are thoroughly boiled for twenty minutes or more, punching them ocassionally. They must be rinsed in several hot waters to ensure the removal of the paraffine, but she claims the clothes will be beautifully white.

A number have advocated the use of kerosene in laundry work, especially with very much soiled articles. Both this and paraffine certainly act upon the oily film which entangles the dirt and thus make the washing easier. The objection to their use is that more

soap and more hot water and therefore more fuel must be used. Two tablespoonfuls of kerosene in a boiler of soapy water is about the right quantity. In this connection it should be said that when clothes are taken from the boiler, they should be put into tepid water, and pushed well into it, for lying in the air seems to set the dirt, probably because the fibres contract as they cool, so that foreign particles are enclosed in the cloth and cannot fall out into the rinse water.

Kerosene is excellent to use in washing dish towels. Make a strong soap suds, putting in a tablespoonful of oil to a gallon of water. Soap the towels well, and boil them in this suds for half an hour or so. Then wash, rinse and dry them, in the fresh air. Kerosene is somewhat volatile, and its odor will escape in time. When kerosene has been used, the wringer, tubs, etc., will need very careful cleaning to remove any film of oil before it has time to catch dust.

BLUING

There are three kinds of bluing now on the market. The action and disadvantages of Prussian Blue have been described. It gives a better color, however, than either of the other two . A second kind is Ultramarine blue. This, also, is an iron compound, but it does not decompose with alkali. It is what we often buy as the "ball bluing," and is insoluble in water. Water, however, causes it to break up into very

minute particles which spread through the liquid and give it a blue color. The water must be kept stirred, and one must be careful in using it that the clothes do not get streaked. The balls of bluing should be tied up in a cloth and washed from this into the water. It is well to prepare it in a separate dish and then add it to the water. Indigo blue is easier to use, but does not give so good a color. Preparations of indigo for laundry work may still be obtained.

Here is a method of cleansing knitted worsted goods which was strongly recommended. Wash the garment in gasoline, and allow it to dry. Then shake it well in a tight box with flour or fuller's earth, allowing it to remain there an hour or more. The powder will absorb any greasy or oily substance, and later may be shaken out. In using gasoline for cleaning in this way, have a generous amount, and allow for rinsing the articles well. The gasoline may be used more than once, for the dirt which it contains will settle to the bottom of the vessel in which it stands and the clear liquid may be poured off. Use it out of doors, or in a strong outward draft, that the inflammable vapors it produces may blow harmlessly away.

To many people, the word "chemical" always means an *acid*. Now, acids and alkalis differ so much in their properties, that it is wise to be able to distinguish between them. Injuries due to the use of one may frequently be remedied by prompt use of the

other. Alkalis are especially useful in laundry work because of their action upon grease of most kinds. Some of the salts formed with the alkali metals are alkaline in reaction. Among these are washing and cooking soda.

HOME SOAP MAKING

All fats and oils are compounds of certain fatty acids combined with glycerine. Glycerine is easily separated from this combination by strong alkalis, and thus soaps are made. The glycerine is a by-product in many soap factories, but it is not evident in home-made soap, being thrown away with any waste water, or, perhaps, left in the soft soap. The various fats are composed of different kinds of fatty acids, so we have varieties of soap made from them.

Rosin acts like fatty acids, for it is able to combine with alkali to make rosin soap. This is good for rough work, but it is apt to separate in hot water, setting free the rosin acids, which may settle upon the fabric being washed, giving it the odor of rosin or causing it to become yellow. It is very objectionable when the clothes come to be ironed. This rosin also makes fabrics likely to take up dust. If the clothes are well rinsed, the amount of rosin soap in ordinary yellow soap gives no trouble.

I have often been asked for a recipe for home-made soap, and, too, I have had many students write me of their success in this process. Many housekeepers

keep and clarify the fats from food. Soap may easily be made from this, as follows:

Take a pound can of lye (Babbitt's potash is good) and dissolve it in three pints of cold water. It will become quite hot as it dissolves, and care must be taken in adding the lye to the water, as it is apt to spatter, and is likely to irritate the hands.

Have ready five pounds of clean fat, which has been melted and strained through cheese-cloth to remove all specks of brown. When the lye is cool, pour it slowly on the grease, stirring it with a stick until the two mix, and the liquid becomes about as thick as honey. Too long stirring may cause the ingredients to separate.

Mould the soap in agate or wooden trays. If a wooden box is used, it should be lined with several thicknesses of wrapping paper. The layer next the soap should be oiled. The soap should harden in a moderately warm place, and then may be cut into cakes. This is the so-called "cold process" soap. It will not be suitable for fine work but improves with age.

Several students have described to me how they remembered seeing soap made at home from alkali obtained by leaching wood ashes. The ashes were put into a large box pierced with holes, the box placed over the soap kettle, and hot water was poured upon the top. This alkali would make soft soap, which would be stored in barrels. If hard soap were desired, salt was added to some of the soft soap.

A reaction takes place by which some of the sodium in the salt is combined with the fatty acids, sufficient hard soap being formed to harden the mass. Nowadays, even when we buy "potash" we are quite sure to find that we can make hard soap, for it almost always is chiefly soda (caustic soap).

Washing soda has a great many uses, and I am frequently reminded of new ones by our students. I am told how excellent it is to put a little in water and boil this in the cooking dishes on which food has hardened or burned. Another describes how she cleans silver by boiling it with a little soda, then rinsing it in very hot water and drying quickly and thoroughly. The wife of a dairy farmer assures me that she could never get her creamery cans suitably clean without plenty of sal soda, which quickly removes the butter fat. When we use it in laundry work, however, we must remember that, like other solids, when it dissolves, a saturated solution forms around each piece, and this strong solution may injure anything on which the pieces rest. Therefore the crystals should always be dissolved, and the solution diluted as much as may seem necessary.

DISH WASHING

The washing of dishes takes so much time in every house that it is evidently a subject calling for close attention. Nothing is more desirable than that this work be done thoroughly and well; still, it is doubtless

possible to plan for it in such a way that time may be saved for other matters.

In the first place, systematic work is sure to go more rapidly than haphazard fashions. The dishes should be prepared for washing by scraping them as clean as possible, and some housekeepers advocate rinsing off many of them under the hot or cold water faucets before putting them in the dish-pan. Hard water is very unsatisfactory for dish washing, and the use of soda or borax is a great help when soft water is not available. Borax is not so hard on the hands as soda. Dishes which have contained milk or eggs are better rinsed well in cool water, for heat hardens the albumins so that they are removed with difficulty.

Plenty of hot, soapy water is necessary to do this work easily, and a second dishpan of clear, hot water in which to rinse the dishes is a great help. Use very little soap on gilt china, however.

There seems to be a great variety of opinion on the subject of washing glass. Many housekeepers have expressed a preference for washing it in cold water rather than in hot. Where the glass is not at all greasy, this is very well. Ammonia or soda in the water helps to clean the glass and makes it lustrous. Glass washed in cold water should be allowed to drain almost dry before it is polished.

One housekeeper has described to me a wire basket which she has had made to hold dishes when they

drain, and which is made to fit into her dishpan. Fitting the dishes into this, she is able to immerse them in hot rinsing water, and then lift them out to dry. She finds the plan an excellent one.

Another student writes that she has found sifted coal ashes a most useful article to use in cleaning knives. Another prefers sifted wood ashes. These must be very carefully sifted, so that no hard bits be left in, which might scratch the articles polished.

The kitchen dishes are usually the most difficult to wash, and one student describes a home-made "scrubber" which she declares is very useful. "Take a broom apart, a good one, by removing the wire and letting the straw loose," she says. "The upper part of the straw is then put into boiling water and left long enough to soften it. Then the straws are tied together in bundles about two inches across, using a strong twine. The twine is pulled tight, and sinks into the softened straw, and when dry, it does not slip. A loop is left for hanging the bundle, and the straw is left its whole length. These are so long and slender they will reach into anything. They are a great saving on the hands, and allow the use of much hotter water."

Many of our students recommend the use of soft paper in cleaning greasy dishes, kettles, and pans, The papers may be burned, thus disposing of much grease which would otherwise find its way into the kitchen sink drain.

LATENT HEAT

The subject of latent heat, described on page 12, has proved very puzzling to many. It is certainly a strange idea at first, that heat does anything more than make things *warm*. Still, a moment's consideration recalls to mind that heat can do many other things. Heat causes chemical change, for substances are often changed by strong heat. Heat causes most substances to expand. If a sealed can of any substance is strongly heated, it will probably explode. Heat causes liquids to evaporate, and solids to melt.

If a liquid is placed in an open dish on a source of heat, its temperature will rise until it begins to boil. After this, it gets *no hotter*, no matter how much heat is applied, unless the liquid is becoming more dense as it boils, as would be the case with a syrup, for example. The heat it receives is all expended in changing the liquid into vapor, or, as we say, changing the "state of matter." The particles (molecules) are driven farther apart by the heat. A cubic inch of water makes a cubic foot of steam. The amount of heat necessary to produce the change from liquid to gas varies with different substances. Water requires a very large amount. Four times as much heat is required to change an ounce of water into steam as to vaporize the same amount of alcohol. If heat is applied rapidly, the liquid will boil rapidly, but it does not affect the temperature. The heat

used in this way is not lost, but is stored up in the vapor as latent heat. The steam is no hotter than the boiling water, and heat added keeps it from becoming liquid. When vapor condenses and changes back to liquid, the latent heat is given out, and warms surrounding things. In fact, the vapor cannot condense unless the latent heat it contains is removed, except under pressure. This latent heat makes steam an excellent medium for heating buildings, as it contains so much heat and passes through pipes rapidly. Not only is the steam itself hot, but it carries a vast amount of heat stored up, to be liberated in the cooler regions.

Latent heat is stored up in water, also, and is liberated when the water becomes ice. This is seldom apparent, for far less heat is thus stored in water than in steam, and, too, the temperature of freezing water is low. The heat given out when water freezes is at 32° F, while that given out when steam condenses is at 212° F. Still, a cellar may be several degrees warmer if it contains a tank of water which freezes than if the water were not there. The temperature may keep about 32° F. where otherwise it might go to 26° or less.

A room is cooled in warm weather by sprinkling water upon the floor. The evaporation of the water takes much heat from the air, storing it in the

vapor produced. Britannia and some other metals of which pitchers, teapots, etc., are made will melt if placed on a hot stove. If, however, they contain water, this is not likely to occur, for the water cannot be heated above its boiling point, and this is far below the melting point of the metal, and keeps the temperature of the metal low enough for safety. This reminds me of an experiment I once saw where candy was actually made in a pasteboard box. The syrup never became hot enough to scorch the paper, and thus the paper itself was kept fairly cool.

USE OF THE THERMOMETER

A kitchen thermometer may be bought of any dealer in the better class of kitchen goods. The floating dairy thermometers are convenient. One to register 212° F, may be obtained from the School for 50 cents. A thermometer made to register oven temperatures is more expensive, one registering to 600° F. costing $1.50. Various uses of the thermometer are described in *Principles of Cookery* and *Home Care of the Sick*, but there are many times in the kitchen when it is of assistance, as in getting the right density for syrups in candy making, for syrups in preserving, and the right temperatures for raising bread, making soups, custards, etc.

Some uses of the thermometer in the kitchen are the following, described in Miss Parloa's "Home Economics":

Olive oil is liquid above 75°. If above this temperature it shows solid specks, making it look cloudy, you may be sure it is adulterated with some fat having a higher melting point.

Butter should melt at 94°. If it does not, you may know it is adulterated with suet or some other fat having a higher melting point.

BREAD MAKING

The composition and manufacture of bread are subjects which have been given much study. The carbon dioxide which serves to lighten the dough raised with yeast is produced at the expense of some of the starch of the flour. This starch is completely driven from the loaf as carbon dioxide gas and alcohol during the baking. The loss is estimated at about 2 per cent. Attempts have been made in large bakeries to save the alcohol, but no economical method has been devised. About fifty years ago, German chemists in studying the question estimated that the food materials lost in twenty-four hours, when bread is raised with yeast, was sufficient to supply bread to 400,000 people! These figures were certainly startling to the thrifty Germans, and the possibility of producing the carbon dioxide gas in some less extravagant manner was studied with considerable care in German laboratories, and also at Harvard University in America. Baking

powders are the result of these investigations. Gluten is not changed chemically by the action of the yeast or of the carbon dioxide, but it is physically changed—the escape of the gases stretching it out into fibres. Gluten, like other proteids, hardens when heated. Baking thus makes the porous condition of the dough permanent.

MAKING BAKING POWDER

Several students have sent me recipes they like to use for making baking powder. The claim is made that these cost rather less than the kinds that can be bought, and also that they are much more effective. Here is one:

½ lb. cream of tartar.

¼ lb. cooking soda (bicarbonate of soda).

⅛ lb. corn starch.

The best quality of each must be bought. Sift them together at least a dozen times, the last time into baking powder boxes. Be careful to seal up all cracks by pasting over them paper strips. About one half as much of this is required as for the average powder sold.

These proportions would probably give a slight excess of acid. We might combine 2¼ parts of the acid salt with one part of soda if our salts are chemically pure. The corn starch is added to keep the soda and acid salt from forming quite such an intimate

mixture. The two salts in contact would very slowly combine, and the baking powder thus lose its strength.

DISTILLATION

A few more words might be said on the subject of distillation. I am sometimes asked to explain more fully the term "destructive distillation." When a complex substance like wood or coal is heated some of its ingredients are made volatile at the high temperature, and so escape as gases. The wood itself is broken up into simpler substances. It is plain that in this process the original substance is lost *as such*, new substances taking its place, and we therefore speak of the process as *destructive* distillation.

When water containing various salts or gases in solution is heated, the gases will be given off as the temperature rises. At the boiling point, the water itself will begin to pass off as vapor. The salts will not vaporize unless much more strongly heated. If the steam be collected and cooled, it will condense to form pure water. This in an illustration of *simple* distillation. If a mixture of alcohol and water be heated some of the alcohol will vaporize before the water. It may in this way be separated from the water, and this process is called *fractional* distillation. This is the principle employed in the manufacture of whiskey, etc.

COMPOSITION OF GAS

The complex nature of coal gas is shown by the following table, which represents an average sample:

Hydro-carbon vapors	0.6
Heavy hydro-carbons	4.4
Carbon dioxide	3.4
Carbon monoxide	10.0
Methane (CH_4)	30.6
Oxygen	0.3
Hydrogen	45.9
Nitrogen	4.8
	100%

Of these, the hydro-carbons, carbon monoxide, CH_4 and hydrogen are combustible.

Coals always contain more or less sulphur, which is a great trouble to the gas manufacturer. It frequently happens that some of it gets into the gas. If such gas escapes, the sulphur compounds unite with the silverware, giving is a coating of dark sulphide of silver. If silver tarnishes quickly, it is an indication of a leak of gas or sewer gas. It is estimated that a ton of coal should yield 10,000 feet of gas, 1,400 lbs. of coke (35 bushels), 12 gallons of tar, 4 lbs. of ammonia.

More than six hundred products are obtained from the coal tar. The nature and uses of these products would form an interesting topic for futher study.

The composition of water gas is somewhat as follows:

Hydro-carbon vapors	1.2
Heavy hydro-carbons	12.0
Carbon dioxide	3.0
Carbon monoxide	28.0
Oxygen	0.4
Hydrogen	31.4
CH_4 (Methane)	20.8
Nitrogen	3.2
	100%

Notice that this gas contains less methane and hydrogen (which are combustible), and their place is taken by carbon monoxide, which, although combustible, is very poisonous. There is some carbon monoxide in ordinary illuminating gas but not nearly so much. The water gas has a strong odor from the hydro-carbons (crude gasoline) added to make it luminous, but comparatively little of it in the air is likely to produce very injurious effects upon living things, plants and animals alike. It is the most poisonous substance that comes into the house. It is estimated that about fourteen per cent of the gas manufactured escapes into the earth through leaky gas mains. In passing through the soil the odorous part of water gas may be strained out, so that it becomes odorless. Whole families have been poisoned from deodorized water gas leaking into the house by way of

the cellar. This emphasizes the importance of having a perfectly tight cellar, with cemented walls and floor, and the importance of ventilating the cellar, for the cellar air finds its way to the rooms above.

Natural gas contains practically no carbon monoxide.

SPONTANEOUS COMBUSTION

We often hear of fires apparently "starting themselves." Such cases are due to accumulation of heat produced by slow oxidation. If a pile of oily rags, cotton waste, etc., be allowed to stand for a time, the oily matter will begin to combine slowly with oxygen. This may occur in the inner part of the heap, and the outer layers retain the heat until, perhaps, the kindling point of some of the inflammable oils is reached, when the whole mass will burst into flame. This is much more likely to happen with linseed oil and certain other vegetable "drying oils," as they unite readily with oxygen, and so become hard and varnish-like. The mineral oils (paraffine oil) do not combine with oxygen at ordinary temperatures, and probably will not cause spontaneous combustion. Still, all oily cloths should be burned or disposed of in some safe fashion.

CONSERVATION OF ENERGY

An interesting and important principle, explained on page 23 of Part I, and again on page 110 of Part III, is Conservatism. This principle has been established by countless experiments, but it is not

one that the housekeeper can well investigate. It is, however, one she must continually bear in mind. Matter and energy can never be *created* or *destroyed*; both may be transformed, and may therefore appear in many different ways. The voltaic cell is a simple device for transforming chemical energy into electrical force. The chemical affinity of two substances causes them to unite under the right conditions. This union results in the liberation of energy, which may appear as heat, light, or electricity. When coal and oxygen unite, we get both heat and light as a result. Chemical union usually produces heat.

The energy of our bodies we get *solely* from the food we absorb. We should eat such foods as best give us the needed energy, and we should learn to expend this energy wisely, as we have but a limited amount of it. One student wisely comments upon this, as follows:

"In the economic plan of housekeeping, it would be well if each one would endeavor to realize that she is a part of the machinery of the household, and that to be continually on the move is as disastrous to the equilibrium of the home as it is to rust, as it were, for want of use. A given amount of rest each day is a true part of economy. Then, too, in the daily regime, there are ways and ways of doing things. Always choose the easiest, if it conflicts not with the quality of the work done. For example, do not stand while paring potatoes, apples, etc. It is just

as easy to do this work sitting, and you can then get some rest at the same time. Don't worry—to worry is a very extravagant thing, for it uses up valuable force, and does no good at all."

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Industrial Alcohol: Uses and Statistics. Farmers' Bulletin No. 269 (free).

Modern Conveniences for the Farm Home. Farmers' Bulletin No. 270 (free).

Composition of American Food Material. Bulletin No. 28. Office of Experiment Station. (Price 5c.)

Some Forms of Food Adulteration and Simple Methods for their Detection. Bulletin No. 100, Bureau of Chemistry. (Price 10c.)

Arsenic in Wall Paper and Fabrics Bulletin No. 86, Bureau of Chemistry. (Price 5c.)

Chemical Composition of Apples and Cider. Bulletin No. 88, Bureau of Chemistry. (Price 5c.)

Note.—For the *free* bulletins, send to the Department of Agriculture, Washington, D. C.; to obtain the *for sale* bulletins, send coin or money order to the Superintendent of Documents Washington, D. C.

SUPPLEMENTAL PROGRAM ARRANGED FOR CLASS STUDY ON

CHEMISTRY OF THE HOUSEHOLD

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As in the study of chemistry and physics so much emphasis is placed on laboratory work, the following supplementary program is made up chiefly of simple experiments, such as may be performed with little or no apparatus. When heat is required, it may be supplied by a small gas stove, a one burner oil stove, or an alcohol lamp. The lamp of a chafing dish might be used. A thermometer will be loaned by the School for 6 cents postage, or one may be purchased for 50 cents.

MEETING I

(Study pages 1–29)

Water

To show that ordinary water has gases dissolved in it. See experiment on page 2. The gas dissolved in water is not exactly of the same composition as air. It usually contains more oxygen and more carbon dioxide than ordinary atmospheric air, varying somewhat with the sources of the water. This dissolved gas enables fish and other marine animals to live. A fish cannot live in water that has lost its dissolved air by being boiled. It is drowned just as human beings are, because of lack of oxygen.

Water of Crystallization

Make crystals as described on page 5. A certain definite amount of water is present in the crystals which varies with each substance. Clear crystals are pure or nearly so. The "mother liquor" remaining after the crystals are formed

contains most of the impurities; thus crystallization is a method of purification.

The water in the crystals of washing soda may be shown by heating some in a tin dish. The crystals will melt and on continued heating, steam will be given off. Not all crystals contain water of crystallization,—for example, common salt, cane sugar.

Boiling Point

It is almost impossible to convince any "domestic" that water boiling furiously is no hotter than when it is just barely boiling. It is instructive to prove this with a thermometer. Also observe that the "simmering" temperature is very nearly the same as the water when boiling, so that cooking may be done nearly as rapidly by simmering and with *far less fuel.*

Latent Heat

This is a somewhat perplexing phenomenon. We all recognize that steam is hot, but that it contains a much greater supply of heat than hot water is not so easy to realize. The following may make this a little clearer: In a small sauce pan or dish put about two tablespoonfuls of water. Heat it to the boiling point and then continue the boiling until it has all boiled away. Note (1) how long it takes to raise the water to the boiling point, and (2) how much time is required to convert it all into steam.

To start the boiling, the water is raised from about 60°F. to 212° F., or through 152°. In converting the water into steam, there is no *rise in temperature*, but the heat has to be applied for a much longer period. On page 12 is the statement that "966 times as much heat is required to change a given quantity of water into steam as to raise it one degree F." but the water in this experiment was raised 150°. As 966 divided by 152 equals 6 (plus), we might expect that it would take six times as long to boil the water away as to

raise it to the boiling point. Of course no exact results can be expected in this experiment, as not all the heat applied is absorbed by the water and used in boiling it, but the experiment will show that the steam must contain a great deal of heat.

A similar experiment will show the latent heat contained in water in reference to ice. If a teaspoonful of ice cold water and an amount of snow or ice which when melted would make a teaspoonful, each be added to a glass of water of the same temperature, it will be found that the pulverized ice or snow lowers the temperature much more than the teaspoonful of ice-cold water. That is to say, a great deal more heat would have to be added to the "ice and water mixture," to bring it back to the original temperature, than to the "ice cold water and water mixture."

Oxygen in the Air

To show that the atmosphere contains a gas which is used up in combustion, attach a candle an inch and a half long to the bottom of a saucer with some of the melted wax. Pour about one-fourth of a glass of water into the dish, light the candle and invert the glass (one with straight sides) over the lighted candle. The flame will grow dim and soon be extinguished and the water will rise about one-fifth way up the glass. This shows a number of things. In burning, the carbon of the hydrocarbons of which the candle is made unites with the oxygen, making the gas carbon dioxide. This takes up the same volume as the oxygen out of which it was formed, but the water quickly dissolves the carbon dioxide and the *pressure of the atmosphere* on the water outside the glass forces it up into the partial vacuum formed.

The nitrogen of the air remains, but this will not "support combustion," and so the candle is extinguished.

Manufacturing Water

That the burning of a candle produces water as well as

carbon dioxide may be shown by placing the flame against a window pane. A film of moisture may be seen, also, when a lamp having a cold chimney is first lighted. The burning of a match will show water when it is placed against a cold surface, but this experiment is not so conclusive, for the wood may contain moisture. The candle contains no moisture, so the water must have been manufactured by the burning.

Atmospheric Pressure

We have had one example of the result of atmospheric pressure in the candle experiment. The working of a siphon is an interesting example. Take a small rubber tube, fill it with water, pinch both ends, put one end in a glass of water, and lower the other end into an empty glass at a foot lower level; release the pressure of the fingers, and the water will run from the tube, apparently going "up hill" over the edge of the glass. The explanation may be found in any text book on physics. This is a good way to empty wash tubs, etc., using a piece of rubber hose.

Carbon Dioxide

Light a splinter of wood and let it burn in a wide-mouthed bottle until it is extinguished. Add a tablespoonful of clear lime water (obtained at any drug store, or add a small lump of lime to warm water in a fruit jar, stir well, cover and let settle over night), close the bottle and shake the lime water around. It will grow milky from the formation of carbonate of lime (calcium), with which we are more familiar in the forms of chalk, marble, and clam shells.

Again with any sort of a tube (a straw), blow into a little clear lime water. It will grow milky, showing that the breath contains carbon dioxide. If you will continue to blow into the lime water for a *long time*, the milkiness will be seen to disappear. This is because the carbonate of lime is dissolved by the excess of carbon dioxide in the water,

after the lime water (hydrate of lime) is all changed into carbonate of lime. This point comes up in connection with hard water and laundry work.

Flash Point of Kerosene

The flash point of a sample of kerosene may be determined approximately by placing about two teaspoonfuls in a cup, then adding hot water to a bowl of water in which the cup containing the oil is placed. Stir the kerosene with a thermometer, and apply a lighted taper to the surface of the oil from time to time as the temperature of the oil rises. A quick flash over the surface of the kerosene will show the flash point. Read the temperature indicated by the thermometer.

References: Chemistry of Daily Life, by Lassar-Conn. Chapter I, Atmosphere, Combustion. ($1.50, postage 12c.)

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MEETING II

(Study pages 29–55)

If the Food Course is being taken, some of the experiments here suggested might better be postponed until the lessons on *Principles of Cookery* or *Food and Dietetics*.

Starch

The blue color produced by a tincture of iodine (obtained at the drug store) on the faintest trace of starch is a very delicate test for starch. Cooked starch shows the test much better than uncooked. Note that the blue color is destroyed by heat, but appears again when the test is cool. Test various foods — grains, vegetables, fruits, and nuts for starch.

The conversion of starch into dextrin may be shown by heating a little flour or corn starch in a hot oven for half an hour or so, or until it becomes a deep yellow color. Dissolve in a little cold water, filter out the unchanged starch by pouring through absorbent cotton in a funnel; test the filtered liquid to see if there is still any unchanged starch in it. Add double the quantity of alcohol to a part of the liquid. The dextrin will be precipitated, i. e., thrown out of solution and will settle as a fine powder,because dextrin is not soluble in alcohol. The water solution should be concentrated by boiling if much is used.

That the starch is changed by heating with butter or other fat may be shown by adding two teaspoonfuls of flour to one teaspoonful of very hot butter, stirring for some time. Remove a drop on a piece of white paper and test it with tincture of iodine.

Make starch paste by mixing a quarter of a teaspoonful of laundry or corn starch with a spoonful of water and adding it to a cup of boiling water and boil. To about half a glass of this when it has cooled to body temperature (100° F) add a half teaspoonful of saliva. Keep the mixture warm (not

hot) for some time by placing it in warm water. From time to time test small portions with iodine solution as it grows clearer. Add saliva to a portion of hot starch; to a cold portion testing as before.

Gluten

May be the gluten separates from flour as described on page 49, or better as described in "Food and Dietetics" page 41. Bake part of it in an oven.

Experiments with other proteids also described on pages 41 and 43 of "Food and Dietetics."

Experiments with yeast described on page 45 of "Household Bacteriology," Part I.

"Digestion is Synonymous with Solution"

This statement is made on page 35. To show the relation of the length of time required to make a solution, take two equal portions of any crystals, such as washing soda or alum, and pulverize one portion. Stir each in a glass of water and observe the time for each in dissolving. Note that the time required for complete solution is determined by the largest crystal.

This experiment shows how important a part of digestion chewing is and that the teeth are primarily digestive organs.

Cooking Meat

See experiment on pages 50 and 51.

Mineral Matter — Gelatin

See experiments on page 53.

References: Chemistry of Cookery, by Mattieu Williams Pages 19-31. Albumen. ($1.50, postage 16c.)
Chemistry of Daily Life, by Lassar-Conn. Pages 56-66. Digestion of Food. ($1.50, postage 10c.)

(Select and send to the School a composite set of answers to Test Questions on Part I, and report on supplemental work and experiments.)

MEETING III

(Study pages 55–65)

Cleaning: Acids, Alkalies, and Salts

Strips of litmus paper may be obtained at a drug store or will be sent from the School on request. Moisten the blue paper in vinegar, lemon juice, tomato, solution of cream of tartar, etc., and then in ammonia (even the vapor will change it), in solution of washing soda, baking soda, borax, soap, and various washing powders. If the paper is washed in running water after being turned blue with ammonia, a test for acid may usually be found in milk, molasses, and sometimes butter. One piece of paper will be found to turn from blue to red and back again to blue an indefinite number of times when wet with solutions of acids and alkalies alternately.

Buy five cents' worth of hydrochloric acid and a little caustic soda at the druggist's. As caustic soda is unpleasant to handle, it is best to have the druggist dissolve it in water. Now pour a part of the acid into a saucer or glass, with a little water, and add the solution of caustic soda until the mixture begins to turn the litmus faintly blue. In an agate-ware dish, free from worn places, evaporate the solution to dryness. A whitish substance will be found, which by testing will be recognized as common salt.

From two very active chemical substances has been formed a neutral substance — salt. Not all salts, however, are neutral. Sodium carbonate (washing soda) is chemically a salt, but it is made up of a very strong alkali forming element — sodium — and a very weak acid — carbonic acid — and the alkali properties predominate. Cream of tartar is an example of an acid salt. It is acid potassium tartrate, which is a double salt, that is, tartaric acid is added to neutral potassium tartrate, the result being a substance which has acid properties. Common alum is slightly acid to litmus paper.

Soap

Soap chemically considered is a salt, made up of a fat acid and the metallic substance sodium. The fatty acid can be separated by adding any acid like vinegar to a solution of soap. If the solution is warm, it rises as a scum to the top. It can be dissolved in ammonia, forming an ammonia soap. The sodium part of the soap unites with the acid and forms a salt. If hydrochloric acid is added to a soap solution (a sufficient quantity to make the solution very slightly acid), the fatty acid removed, and the residue evaporated to dryness, common salt will be found.

If lime water be added to a solution of soap, white clots of "lime soap" will be formed which are insoluble in water, but on collecting and drying will be found to dissolve in gasoline, naphtha, or kerosene. This is why naphtha or gasoline is useful in cleaning bath tubs, bowls, etc. Quite a good varnish can be made of aluminum soap, made from alum and white soap, dried and dissolved in gasoline.

Washing Powders

It is not difficult to get some idea of the composition of the various washing powders on the market. When acid is added to a solution, if there is effervescence, washing soda is probably present. A skum would indicate that soap formed a part of the mixture.

Hard Water

In the experiment with cabon dioxide it was shown how carbonate of lime might be dissolved by an excess of carbon dioxide gas, the bicarbonate of lime being formed, which is soluble in water. This is an example of an "unstable" chemical compound. Simply boiling drives off the excess of carbon dioxide gas, leaving the ordinary carbonate of lime which is insoluble and is deposited on the sides of the tea kettle or other vessel. This may be shown by blowing into lime water until the cloudiness which at first appears begins

to dissolve. As it is difficult to dissolve it completely, the solution may be filtered. On boiling the clear solution, the milkiness will appear again.

Hardness that is brought about by the sulphate of lime — "permanent hardness" — is difficult to remedy by any household means. Washing soda helps a little, but not very much. The so-called alkali waters of the west, in addition to sulphate of lime contain sulphate of soda and other salts, so that they are beyond remedy.

Reference: Chemistry of Daily Life — The Manufacture of Soda. Page 194.

MEETING IV

(Study pages 66-88)

Laundry Work

Bluing May Yellow Clothes: On page 70 is the statement that the repeated use of ordinary bluing may stain the clothes yellow. To prove this, dip a piece of white muslin into a strong bluing solution — about a teaspoonful of liquid bluing to a cup of water — dry the cloth with a hot iron and boil it in a little strong soap solution. The color will be seen to fade. Rinse and dry with the iron. On comparing the cloth with part of the original piece, a slight yellow stain will be seen. This is oxide of iron (iron rust) and can be proved to be such by adding a drop of pure dilute hydrochloric acid and then a drop of yellow prussiate of potash (potassium ferro-cyanide), the intense blue color produced being a test for iron. The conditions in this experiment are, of course, much more severe than obtained in ordinary washing, as most of the bluing is washed out before the clothes are boiled again, but the experiment proves the possibility. As indigo costs about a dollar a pound and Prussian blue only a few cents, practically all the bluings on the market are Prussian blue.

Iron Rust Stains

Make "rusty water" by letting a few nails stand in a can of water over night or longer. Boil some white cotton cloth in a little of the water. Try the same with wool. Strain some of the water through white muslin and boil the muslin in soapy water.

Stains

One of the classes gave a demonstration before a large audience on the removal of stains as outlined in this lesson. As the only way to learn how to remove stains is to *remove stains*, it would be advisable to make a few, if none are at hand, and then try the experiments on them.

References: Chemistry of Daily Life—Inks. Page 178.
Laundry Work, by Juniata L. Sheppard. (50c., postage 6c.)

(Send answers to Test Questions on Part II, and report on supplemental work.)

MEETING V

(Study pages 89-111)

Baking Powder

Perform experiments suggested on pages 90 and 91.

Reference: Baking Powders. Bulletin No. 119, Maine Agricultural Experiment Station. (Loaned for 2c.)

Lighting

(1) See Experiment page 93.

(2) Insert the small end of a clay pipe stem in the inner part of a candle flame and touch a lighted match to the other and so prove that the candle is a "gas factory."

3) With a piece of wire gauze make the experiments illustrated on page 95.

(4) Visit the local gas plant if there is one—or the electric light station—obtaining permission first from the office.

Electric Batteries

(1) Detach one of the batteries that furnish the current for the electric bell, attach a wire to each pole and place the other ends on the tongue and note that the electric current gives a slight "taste".—i. e., stimulates some of the nerves of taste.

(2) Get some one to explain the action in an electric bell or send 2c. stamp to the School for circular giving descriptive diagram, diagrams for bell wiring, etc.

Plants

Examine with a microscope the "breathing pores" on the under surface of leaves.

MEETING VI

(Study pages 111-122)

Chemical Formulas

Reference: "Chemistry of Cooking and Cleaning," by Richards and Elliott. Pages 9-30. ($1.00, postage 10c.)

"Elementary Chemistry." Text book of American School of Correspondence. (Postage 4c.)

Housekeepers' Laboratory

Make some of the tests described.

Reference: "Some Forms of Food Adulteration and Simple Methods for their Detection." Bulletin No. 100, Bureau of Chemistry, U. S. Department of Agriculture. Send 10c. (coin) to the Supt of Documents, Washington, D. C.

(Send answers to Test Questions on Part III and report on supplemental work.)

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